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Research for Small Farms

Proceedings of the Special Symposium

Howard W. Kerr, Jr., and Lloyd Knutson, Editors

Invited papers presented at a symposium held November 15-18, 1981, at the
Beltsville Agricultural Research Center, Beltsville, Maryland 20705

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THIS SPECIAL SYMPOSIUM PROVIDED....

"Papers, then Q&A, then meeting and mingling." B.P. (NJ)

"Presentations of new, practical ideas about approaches to small-scale agriculture." M.M. (AR)

"Finding the void that's affecting the progress of small farms." W.K. (MD)

"A broad-cross-sectional view of the problems of small-scale agriculture." E.J. (NH)

"Generally, that attention is being paid to small farmers in today's changing world." J.S. (PA)

"Opportunity to meet a broad spectrum of people who are deeply concerned with the future." S.S. (MA)

"Exchange of information, quality of speakers." D.R. (Canada)

"The recognition of the small farmer as well as the hope it generated for the chance that its existence and productivity can further be studied and enhanced in the future." F.B. (MD)

"Overview of problems and real lack of progress across the country." D.F. (DE)

"The symposium has stimulated possibilities for my own farm and given me information for the Environmental Board." W.J. (VT)

"What small farms need to examine in terms of production - Crops that make the small farmer money." C.M. (PA)

"Opportunity to meet others with some or similar interests and goals; exchange of current information." G.C. (FL)

"Talking to other individuals attending, looking for solutions to their problems." M.H. (ND)

"Actual examples of innovative farming experiences outside of USDA." G.N. (DC)

"Meeting people and thereby gleaming ideas." R.T. (MD)

"Overview of thinking and plans regarding small farms research." D.L. (VA)

"The exposure to many ideas and the opportunity to meet and talk with farmers, researchers, etc." P.M. (NJ)

"Talking with people about the problems of small farms, the potentials and desirability of small farms." S.G. (NY)

"New information of use in small farming; reports on current research in progress; new ideas." V.D. (NY)

AND IN ADDITION....

"Small farmers do exist, have needs, hope for help and information may be forthcoming." W.K. (MD)

"I question the concept that agricultural research is size neutral. The fact that this Symposium was held is significant recognition of new trends. It was very helpful to me in gaining background in agricultural issues that I was formally trained in." E.L. (ME)

"I was impressed by the congeniality of all the participants. No cold shoulders. The mixing of farmers with scientists was appreciated." N.M. (MD)

"....the Symposium was beautifully organized and an important gathering in the on-going effort to accomplish something of lasting significance." S.S. (MA)

"Scientists at USDA must review their findings with Extension personnel to make them more rapidly available to and easily understood by their ostensible recipients." W.L. (NY)

"I think that food pressures in the coming decades will require that we begin producing crops on all available land, much of which may be marginal for large scale farming, but which can be handled carefully and made productive on a small scale. But we all are going to need much more help from USDA to accomplish this. Let's get going!" A.L. (ME)

"It gave me an overall understanding of the small farmer and the problems he faces." R.W. (MN)

"Sensitization of a non-farmer like myself to realistic knowledge of small farms problems; needs, especially information dissemination to farmers." V.D. (VA)

"A wide variety of topics - the brevity was excellent yet presentations were very good." M.M. (KS)

"You need more farmer input." L.H. (CA)

"Needed greater participation by small farmers, so communication can go two ways." J.C. (VT)

"Research data is fine if it's used. Research people need to get out and apply the needed technology in the area of small farms. New England States have lost a large portion of their agricultural land, they are now very aware of their situation. Let's not make the same mistake in Maryland, as well as the rest of the Northeast." F.B. (MD)

"More opportunity than I expected for organic farming methods to be recommended." J.T. (NJ)

"A valuable conference - should have others on small farms." C.S. (PA)

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PURPOSE OF THE SPECIAL SYMPOSIUM

"Research for Small Farms"

Howard W. Kerr, Jr., and Lloyd Knutson
Symposium Co-chairmen 1/

Small farms constitute the majority of agricultural enterprises in almost all countries. However, during the past half century their actual and potential contributions have been overlooked in many areas. Now, shrinking energy supplies, the increasing world population, the need for increased food production, and, in the United States, the migration of populations from urban to rural areas, have focused attention on the need for and needs of small farms. The issue confronts us now and will continue to do so. The purpose of the BARC Small Farms Symposium is to identify research needs, report research achievements, foster rapport of involved parties, provide information for small farmers, and record the status of various efforts to enhance the well-being of this special segment of our agricultural life.

Small farms are diverse enterprises that have considerable flexibility in modes of production and marketing. That diversity and flexibility accounts for a substantial part of the increasing need for research directed to this audience. The information needs of small scale livestock and dairy producers and vegetable and fruit growers have increased recently, as have those of many other kinds of small farm businesses. The production, marketing, environmental, and socioeconomic concerns and shifting special requirements of these farmers have expanded as demand for their products has increased. Over the past few years, the results of specific small farms research projects have begun to fulfill the growing needs of small farms operators. The great potential for small farms to become an even more important and viable segment of agriculture, and the research needed to accomplish this, especially in the Northeastern United States, are the focal-points of the 1981 BARC Special Symposium.

1/ We thank the many people involved in planning, presenting, and participating in this symposium.

WELCOMING REMARKS

Paul A. Putnam, Director
Beltsville Agriculture Research Center

Since 1974, the Beltsville Agricultural Research Center (BARC) has sponsored a major annual symposium on a specific aspect of agricultural research, such as plant reproduction (1981) and the application of genetic engineering (1982). These symposia, which have become highly respected, provide scientists with a means of exchanging ideas among themselves and of reporting achievements to the public.

Small family farms are experiencing a comeback in America. In 1979, Congress recognized this resurgence by appropriating specific funds for research on small farms needs. BARC was one of the centers in the Northeastern Region to receive funding. Over the 3-year period, the small farms research program has expanded, and the results of this research are now available.

Although small farms can use the discoveries of scientific agriculture in general, they have specific needs that are a special challenge to researchers. At BARC, we are involved in a variety of activities to aid small farm agriculture. This Special Symposium is part of our broad plan of assistance. By working with colleagues such as you who are participating in these meetings, small farm agriculture should certainly be helped.

I welcome you to Beltsville and we, the administrators and scientists, hope that this Special Symposium will renew your enthusiasm to contribute to the well-being of the small-scale farmer.

INTRODUCTION TO SYMPOSIUM

Lloyd Knutson
Chairman, Insect Identification and Beneficial
Insect Introduction Institute

On behalf of Howard Kerr, the Co-Chairman of this Symposium, and the 59 contributors and 70 advisors and committee members, I would like to open the Beltsville Special Symposium, "Research for Small Farms." We thank you, the 500-some participants, for joining us.

Perhaps, at the very beginning of this Symposium, it would be useful to consider the general objectives for a minute. When the planning was getting underway about a year and half ago, the purposes as described on page were outlined, and they have evolved somewhat since then. In essence, we have felt that it would be important to report research results and provide information for farmers, to identify research needs, to discuss a wide range of activities relative to small farms, and to encourage communication and cooperation amongst all involved. At this point I think we can say that it is likely that the objectives -- which are not simply those of the organizers, advisors, and commitees but their attempt to define some of the general interests in small, family farms -- will be reached.

But some other things besides the stated objectives probably can be achieved during these two and a half days. Some are even now obvious and some, hopefully, will emerge.

We think that this symposium will be significant because of the quality and diversity of the presentations, the timing of the Symposium in relation to other discussions of the broad issues of agriculture and agricultural research, the fact that there is renewed interest in small farms in many circles, and because of the excellence of the audience.

The fact that we are concerned here with a relatively new set of elements in the focus and use of research is important. This kind of situation is stimulating to researchers. They relish the challenge and unpredictability of this kind of situation. This focus, this situation, should surely provide new research planning, and it is. The funds made available for small farms research are providing the opportunity for something to emerge that did not exist before--for research to be done in a different way.

During this Symposium, we can also be on the lookout for opportunities for actual technology transfer, and approaches that may lend themselves in this way. Such needs are in the background, at least, of certain papers, and explicit in others. Also, because of the diversity of interests of the users of research for small farms, and because of their distribution, geographically and in society, there seem to be rather unique opportunities to educate, further, many highly receptive people about agriculture and agricultural research. To explore some of the linkages, connections, in the small farms phenomenon, especially relationships relevant to research, is one of the objectives of this symposium: linkages such as small-to-large, urban/suburban-to-rural, farmers to consumers and vice-versa, international transfer of technology (both ways), educational, federal-state and private organizational linkages, commercial to governmental, and so forth.

A symposium should be a symposium, in the true sense of the word. There comes a point when the instigators and planners need to back away and let the magic of the moment take place - this Symposium is now in your hands.

I would now like to introduce Dr. James L. Hilton, Chairman of Session I.

WHAT IS A SMALL FARM?

David E. Brewster, Historian
Economic Research Service

What is a small farm? The answer varies by type of farm, location, even by individual--and it has varied historically, too.

The 160-acre farm of the 1862 Homestead Act seems to have been considered a small operation at the time, even though it was big enough to use the most sophisticated technology of the day. It was small in the sense that the family did most of the work, unlike the Southern plantation or the hacienda of the Mexican-American West.

During the decades after the Homestead Act, improvements in farm tools and techniques increased the skills and capital investment necessary for successful farming. The family still might do most of the work. But the family could operate a much larger enterprise than before if its members were fully employed. Farms that supported and fully employed the families living on them came to be called family farms. Yet many operations were too small to keep a family busy on a full-time basis. By the 1940's, these were the places that people generally had in mind when they talked about small farms. Unlike family farms of the period, small farms at that time were usually considered to be part-time operations, retirement residences, or subsistance farms.

Farm size after 1950 was most commonly measured in terms of sales--not acres of labor requirements--and small farms came to be seen as the production units that accounted for a declining portion of the agricultural market. In the 1960's, when $10,000 in annual sales marked the dividing line between operations that survived and those that did not, small farms were said to be units selling less than that amount. The dividing line had crept up to $20,000 by the mid-1970's. In effect, small farms during these years were defined as places in trouble--operations that were dead or dying.

USDA's agencies, in recent years, have tended away from a small farm definition based on sales. A three-part definition is now frequently used. It describes small farms as operations on which:

> The family provides most of the labor and management.
>
> Total family income from farm and non-farm sources is below the median nonmetropolitan family income in the state.
>
> Farming provides a significant portion, though not necessarily a majority, of the family income.

This definition emphasizes the farm family, rather than simply the farm, and it takes into acccount income derived from the family's entire set of resources--farm and non-farm alike. An important goal of a small farm policy based on this definition is to raise the family's income from both sources. Small farms so defined may prove to be one of the most resilient segments of U.S. agriculture in the years ahead. The combination of farm and non-farm income should help families weather periods of low prices and allow many to remain in farming who would otherwise be forced to leave.

THE HERITAGE OF SMALL FARMS- AN EXHIBIT OF PHOTOS, BOOKS, ARTIFACTS

Alan Fusonie
Historical and Preservation Program Specialist
National Agricultural Library

Since colonial times, the small farm family has played an integral part in the development of the American food supply. During the formative years of the new nation, many farm families were anxious to improve their lot in life. Limited agricultural surplus was often created to use as barter for nonfarm items such as salt, coffee, and gunpowder. From the beginning, Pennsylvania farmers were producing wheat for cash sale. The success of the small farm family operation was often measured by the amount of back-breaking work, accomplished especially in the forested regions of this country where it took about 10 to 15 years to develop a commercial type of farm operation. The many small farm families hard at work clearing, plowing, seeding, harrowing, cultivating, harvesting, haymaking, and other chores came to symbolize the democratic aspirations of the new nation. In expressing his appreciation for their efforts, Thomas Jefferson said, "...small land holders are the most precious part of a state."

Travel westward across the Alleghenies was by wagon, horse, and on foot, was plagued by physical and discomfort. During the first year of settlement, west of the Alleghenies, the farmers' survival depended upon the partial clearing of forested land and the planting of corn among the stumps or upon the breaking of the prairie sod. Gradually, the pressures of an expanding market system - characterized by the spread of the country store, credit, capital investment - stimulated many family farms to become more involved in commercial-type agriculture. Improvements in turnpikes as well as water travel encouraged farmers to produce crops for an expanding and more accessible market economy. The small-propertied farmer was usually the first one to illustrate the productivity of each new region.

Between 1830 and 1860 the mechanical reaper was probably the most significant invention introduced into farming. During the decades after the Homestead Act, improvements in farm tools and techniques increased the skills and capital investment necessary for successful farming. The 1860's and 1870's saw horsepower replace human muscle in the fields. By 1860, there were approximately 80,000 reapers in service to American Agriculture. No longer did the farmers in good wheat country depend on the time-consuming expert labor of binders and cradlers.

Between 1870 and 1900, farmers found themselves producing more in order to pay for their more expensive and sophisticated technology of the day. Unfortunately, overexpansion and recurrent surpluses kept prices low during the period. Usually, the combination of low prices and crop failure meant the end of the farm family with marginal capital. Progress of the farm family was often realized despite the adverse living conditions and environment such as are vividly portrayed in Everett Dick's The Sod House Frontier and O. E. Rolvaag's Giants of the Earth.

By 1900, the total animal power on the farms--18.5 million horsepower--had tripled the estimate in 1850 and only 38 percent of the gainfully employed were engaged in agriculture. Between 1919 and 1921, a post World War I farm depression resulted in a net loss in total farm income of 5.7 million dollars. Post war decline in foreign markets and increased wheat production in the wheat plains during the 1920's ultimately lead to recurring surpluses and low prices. By the time of the Great Depression of the 1930's American agriculture was a poverty stricken livelihood for many farm families, resulting in a net migration from the farms of 3.8 million. In the Great Plains, drought and dust storms added human misery to the economic distress.

By the eve of World War II, American agriculture had accumulated, through years of research efforts, a vast storehouse of available technical knowledge. Unfortunately, the post war commercial farm families with small land holdings, undercapitalization, and declining markets found it next to impossible to afford the improved products of the technological and chemical revolution. As many small family farmers were forced to take the road to the city, the remaining small farms came to be identified as part-time operations, retirement residences, or subsistence farms. Commercial farm operations decreased in number yet expanded in size.

Between 1940 and 1960, the net migration from the farms was 17.5 million people. Today, what remains of the small farm family enterprises is being recognized as an important part of the American economy and heritage. Today, about 75% of small farms are part-time operations.

With shrinking energy supplies, population explosions in developing countries, and the spectre of food shortages, some forecasters advocate an immediate increase in agricultural productivity by the United States. Increased support for expanding technology and research to include small farms will surely benefit all farms as well as long range efforts to deal effectively with the challenges of world food and agricultural needs.

(Note: A descriptive list of the agricultural implements and machines on display were available during the Special Small Farms Symposium)

ARS SMALL FARMS RESEARCH PROGRAM

Steven C. King 1/

ABSTRACT

ARS small farms research programs are concentrated in the Northeastern and Southern Regions and coordination is achieved through focal points at Beltsville, Maryland; Charleston, South Carolina; and Boonesville, Arkansas. The Northeast is forecasting an expansion in numbers of farms in the small farm category. Major research activity centers on problems in fruits and vegetables production, forage and pasture, and postharvest technology. Small farms today represent more of a way of living than survival or subsistence farming. Northeastern Region research programs involve a strong partnership approach with the State agricultural experiment stations.

Keywords: Small farms, Agricultural Research Service, Northeastern Region, current research program, extramural research

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1/ Regional Administrator, U.S. Department of Agriculture, Agricultural Research Service, Northeastern Region, Beltsville, Md. 20705.

INTRODUCTION

My position title identifies me as the Regional Administrator of the Northeastern Region (NER) of the Agricultural Research Service (ARS). However, my assignment today is to discuss the ARS small farms research program. The Nation has 2.4 million farms of which about 1.35 million are classified as "small farms." Nationally, this turns out to be about 95 people per farm. We manage to feed all these people off the production of each farm and still export a net surplus of $25 billion worth of farm products.

It is appropriate for me to talk about small farms research in ARS when you realize that the 12-State Northeastern Region, which includes New England, New York, New Jersey, Pennsylvania, Maryland, Delaware, and West Virginia, is inhabited by nearly 56 million people. We have 298 counties, with over 206,000 square miles of which nearly two thirds is forested. For the Nation as a whole, only one third is forested. The Northeastern Region has nearly 191,000 farms. That means we have about 288 people per farm. Since we have at least 107,000 of our farms classified as "small farms" it is obvious that most of our food comes from the other regions and that "small farms" problems are important in the Northeast.

USDA DEFINITION OF "SMALL FARM"

Before launching into a discussion of the ARS small farms research program, I will review for you the current USDA definition of "small farm." The following quote is from a report of the Ad Hoc Committee on Small Farms of the Joint Council on Food and Agricultural Sciences, December 1979.

"The current USDA definition of small farm is based on the following factors:

--Family net income from all sources (farm and nonfarm) is below the median nonmetropolitan income of the State.

--The family is dependent on farming for a significant, though not necessarily a majority, of their income.

--Family members provide most of the labor and management.

This is a useful definition for the purposes of identifying those small-scale farm facilities most in need of assistance. There are an estimated 1 to 1.3 million farms that fall within the context of this definition. However, there are an estimated 700,000 small-scale farmers (sales less than $20,000) with net family income above the median nonmetropolitan income. These farms should also be viewed as users of information and technology that is developed by the agricultural science and education system for small-scale farmers."

THE FISCAL YEAR 1979 "SMALL FARM" INITIATIVE

Small farms research was first identified as a separate budget initiative in the ARS budget for fiscal year 1979. The Agency position had been that its research was not size specific, but there was growing concern that large farms were more likely to benefit from our research. As more people sought out a rural way of life while continuing urban jobs, the part-time, small-scale farmer reversed the trend toward fewer farms in many localities. Policymakers began to feel that small-scale farmers had specific needs that deserved attention.

Until we began to realize that the problem was not how to enable a small farmer to become a big farmer, but one of enabling a small-scale operator to continue a way of life successfully, we had difficulty planning research programs within the small farms appropriation. You see, most of us had personal experience, either on small farms making the transition to large farms or on small farms going out of business in favor of off-farm jobs.

Now, with three years of small farms research behind us, we can look at current small farms research programs to see what has evolved. Scientists' attitudes have changed. No longer do they ask what can I do, now they want to know where are the resources to do it. We have a growing list of problems that need to be solved and accomplishments coming out of our laboratories and plots that help small-scale farmers cope with their individual situations.

HOW THE SMALL FARMS PROGRAM DEVELOPED

The fiscal year 1979 budget for the Agricultural Research Service proposed $3.5 million for small farms research. It was conceived of as an extramural research program. The USDA appropriation came out of the Congress as a $3.0 million program with $2,250,000 allocated for intramural and $750,000 for extramural research. The National Program Staff (NPS), our commodity, resource, and scientific staff specialists, was responsible for developing an ARS program and for recommending the initial allocation of funds.

In the beginning, most of the funds were made available to scientists who had research underway that largely met small farms objectives already or who were able to shift emphasis to meet small farms objectives. Subsequently separate projects were written and specifically documented as small farms projects.

Geographically, emphasis was very heavily weighted to the Appalachian Region where most farms are small in acreage and soils are predominantly marginal. However, patches of good soils exist mostly as river bottom lands. During the debate over FY 1980 appropriations, political forces drew attention to small farm needs centered around Boonesville, Arkansas. As a result, the ARS concept for small farms research developed into thrusts oriented to concentrations of program at three centers--Beltsville, Maryland; Charleston, South Carolina; and Boonesville, Arkansas. The Charleston center would give major emphasis to vegetable production; Boonesville to fruits and vegetables and forage-livestock; and Beltsville to fruits and vegetables and forage-livestock.

CURRENT PROGRAM

Our latest summary of current small farms research in ARS reveals how the program has developed. Table 1 shows FY 1981 research plans by Scientist Year (SY) and dollars for each National Research Program (NRP) that had a small farms category.

Table 1.--Small Farms Research in ARS as Indicated by CRIS* for FY 1981

NRP#	Title of National Research Program (NRP)	SY	Dollars
2001	Fruit nut & specialty crop production	2.49	499,850
2002	Vegetable production	0.52	113,361
2010	Forage crops, pasture and turf	2.52	719,875
2019	Equipment for production and harvesting	0.30	41,948
2022	Horticultural crops insect control	2.26	310,821
2027	Disease and nematode control	1.82	244,993
2028	Weed control tech.	4.07	472,033
2035	Dairy production (goats)	0.23	71,527
2038	Sheep and other animal production	0.24	189,160
2045	Disease control - poultry	0.21	35,901
2051	Process fruits and vegetables	3.43	454,907
2053	Process animal products	2.81	274,504
2058	Marketing horticultural crops	0.81	109,183
2078	Soil fertility	3.52	309,768
	TOTAL SMALL FARMS	25.23	3,847,831

*Current Research Information System

If we further consolidate these categories of research on small farms problems, we have a broader look at our programs in Table 2.

Table 2. Small Farms Research by Broad Category - FY 1981 Plans

Category	SY	Dollars
Soil fertility	3.52	309,768
Fruits & vegetables prod.	8.93	1,400,993
Forage & pasture	5.05	1,001,888
Livestock & poultry	0.68	296,588
Postharvest technology	7.05	838,594
TOTAL	25.23	3,847,831

I hasten to point out that the way the actual expenditures turned out in FY 1981 are different than the planned figures, but probably not of much significance. Also, we have trouble in accurately reflecting actual amount of research done under extramural programs because of the way we record contractural obligations in CRIS. For example, a 2-year contract or agreement will show all of the expenditure in the year obligated but the work carried out over a 2-year period. Among these anomalies is nearly $300,000 in agreements on forage/livestock research in the Northeastern Region which was obligated late in FY 1981 and was not reflected in Tables 1 and 2. Nevertheless, the tables do give one a feel for the kinds of research covered and the approximate levels of effort.

Research Programs in the Regions

The small farm problems vary in the four ARS Regions and different approaches have been used to develop research programs to solve the problems. The Northeastern Region is characterized by a highly urban area, which over the past century absorbed the labor and other resources that shifted out of farming. About one fourth of the U.S. population lives in the Northeast. Unlike the rest of the country, the number of farms in the Northeast is increasing and the average farm size is declining. There is a "back to the land" movement on the part of urbanites and suburbanites. Small farms are often part-time operations and represent a way of life more than a way of earning a living. The growth and business prosperity of the Region's small farms are expected to increase about 17 percent in the next 5 years, especially for farms near metropolitan areas. At present and looking ahead, no other Region in the United States will require technology improvements gained from specially targeted research projects for small-scale agriculture more acutely than the Northeast.

Research is conducted on a wide variety of agricultural subjects. During 1981 there were more than 50 small farms research projects supported by the Northeastern Region of ARS at an appropriation level of $1.8 million. Of these, 38 are either at Beltsville or cooperative with Beltsville. You will hear about results from many of these projects later in the Symposium, so I will not attempt to steal any of their thunder.

I do want to say a few words about our extramural program. The Northeastern Region set aside approximately $300,000 of its small farms resources for a Regional research program patterned after the Hatch Regional Research Program. Experience with that program has demonstrated the value of scientists cooperating on individual projects that are integrated in support of one or more major objectives. The result was a general improvement in quality of research due to increased communication among scientists and the tendency of technical committee meetings to simulate a peer review process of project planning and progress reports.

Our approach to allocation of small farms extramural resources was to propose to an ad hoc group of ARS and State agricultural experiment station (SAES) administrators that we try following the procedures employed for Hatch regional research funds. This, we hoped, would stimulate innovative thinking about research to solve small farms problems and to enhance cooperation between these agencies. We jointly made the decision to divide our effort into two broad areas--forage/livestock management systems and horticultural crops. We proposed to fund the research projects that were approved through cooperative agreements that would run about 2 years. We further decided to start the first year with forage/livestock and shift to horticultural crops the second year, alternating thereafter.

The pattern of organization has been to appoint a technical committee to draft a master project outline and then to invite the submission of contributing projects. The technical committee was asked to evaluate and rank the project proposals. As administrator of the funds, I approved and funded the top ranked projects as far as the funds would go. As an Agency, we are pleased with the progress. It has stimulated good thinking in terms of master project development and in contributing projects funded. We have completed the first cycle for awarding funds to both master projects and conclude that we gained from the process a high level of enthusiasm and innovation.

Following another practice that Hatch Regional Projects have used, we are encouraging review of inhouse projects. One goal is to see whether benefits would accrue by having some of them become contributing projects to the master project programs. Our hope is to foster communication and to develop cooperative efforts between ARS and the SAES. We think it is working.

Small farms research programs have taken into account the economics of small scale farming and the special marketing problems arising out of production from small farms. Some livestock disease and parasite research has been funded outside the areas generally thought of as "small farm regions" in order to take advantage of specialized research experience available.

The ARS National Program Staff has a Small Farms Research Committee consisting of the National Research Program Leaders (NRPL's) interested in small farms research. This committee has the overall responsibility for planning the ARS research for small farms, recommends allocation of resources to the Administrator and reviews research progress. Thus, research carried out in the Regions must meet the approval of NPS and regional planning must fit in with the overall ARS plan.

Since nearly one half of the total small farms research program has been allocated to the Northeastern Region, we have been aware of our special responsibility. Early in the development of the Northeastern program, we saw the need for coordination and carefully targeted planning, so we designated a coordinator for our small farms research program. Howard Kerr has been our Coordinator from the beginning and no one can say he has not been involved or lacked commitment. In fact, his drive and enthusiasm are evident in this Symposium and I want to pay tribute to his efforts to make our small farms program a success.

ECONOMIC ASPECTS OF SMALL-SCALE AGRICULTURE

Luther G. Tweeten[1]

ABSTRACT

This report shows that the small-farm sector has been transformed from a conglomeration dominated in numbers by full-time farm operators to one dominated by part-time farm operators. In the process, the small-farm sector has been transformed from a sharply declining backwater to a dynamic, growing part of American agriculture. No longer can we view the modal small-farm family as underpaid and undereducated but rather must view it as middle class. Agricultural output from small-scale farms is low but not necessarily inefficient viewed in the context of the consumption value which nonfarm workers derive from rural residence. Although the educated new small-farm sector has the capacity to respond to the traditional approaches for delivering information from research and other sources, the time of operators to seek and use information is no longer a plentiful resource.

Paraprofessional programs to reach small farmers have brought favorable economic returns which are compared to payoffs from conventional extension programs in this study. Although intensive, high-cost, public research and extension delivery systems are difficult to justify for middle-class, part-time farmers, it must be recognized that many low income, limited-resource farmers remain, and they need diversified public programs for agriculture production, work force development and, in some cases, welfare.

Keywords: Agricultural enterprises, agriculture, economic unit, economics, economies of size, extension, farmers, paraprofessional, research, small-scale farms.

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The purpose of this paper is to outline what we know and would like to know about the economics of small-scale farming in the U.S. The central thesis is that the small-farm sector is no longer an anachronism of farmers destined to get big or get out, but rather is a dynamic, growing part of agriculture. To be sure, the small farm will remain more of a utility-maximizing than profit-maximizing institution. But the changing makeup of small farms must be recognized if sound research and extension programs are to be devised to serve the economic needs of small-scale and other farms.

Farm size is defined in this paper in terms of scale of operations in part because that is my assignment and in part because small-scale farms share many problems in production and marketing. Although scale is best measured by resources or assets controlled by the farm operator, availability of data frequently dictate defining scale herein by annual sales of crops and livestock.

The outline of this paper is to first present trends in the composition of small farms; then summarize data from past research on the economics of small farms. This background serves as the springboard to discuss future directions for research and extension to serve small-scale agriculture.

Economic principles of small-scale farms are the same as those of large-scale farms. The principles deal with how to allocate scarce means among competing needs to satisfy those needs as fully as possible. It is the means (human and material resources and technology) and needs (goals, objectives, wants) that separate the economics of small-scale and large-scale agriculture. Means and needs are reviewed along with trends in the following section.

CHARACTERISTICS OF SMALL-SCALE FARMS

Tweeten et al. (18) previously examined historic trends in numbers of U.S. farms with annual sales of $2,500 to $20,000 divided into three categories based on characteristics of the household head: Farms with (1) a head over 65 years of age, (2) a head working 200 days or more off the farm annually, and (3) a head who is an able-bodied, full-time farm operator depending on the farm for a livelihood - - defined operationally as all small farms less categories (1) and (2). The three categories are arbitrarily called aged, part-time and bonafide, respectively.

Based on this classification, trends in numbers of small farms are presented for Oklahoma in figure 1. U.S. trends are not presented because 1978 Census of Agriculture data were not available for the U.S. as of this writing. Trends for Oklahoma presented for 1959-74 closely parallel trends for the U.S. presented elsewhere (18, p. 84), hence figure 1 provides insights into U.S. trends from 1959-1978.

The rise of the part-time group and demise of the bonafide group is dramatic. Because numbers of aged small farmers will hold steady or decline in the future, small-farm numbers once heavily dominated by bonafide farms will be dominated by part-time farms. Following decades of decline, the number of small farms in Oklahoma increased from 1974 to 1978 even after adjusting for inflation and the 1974 Census of Agriculture undercount using U.S. data from Lin et al. (10, pp. 37, 73). The growth in small farms was sufficient to offset a reduction in number of mid-size farms in Oklahoma, leaving the number of farms in the state nearly the same in 1974 and 1978. Similar trends are expected for the nation. Discussion of the far reaching implications of the transition is deferred until later.

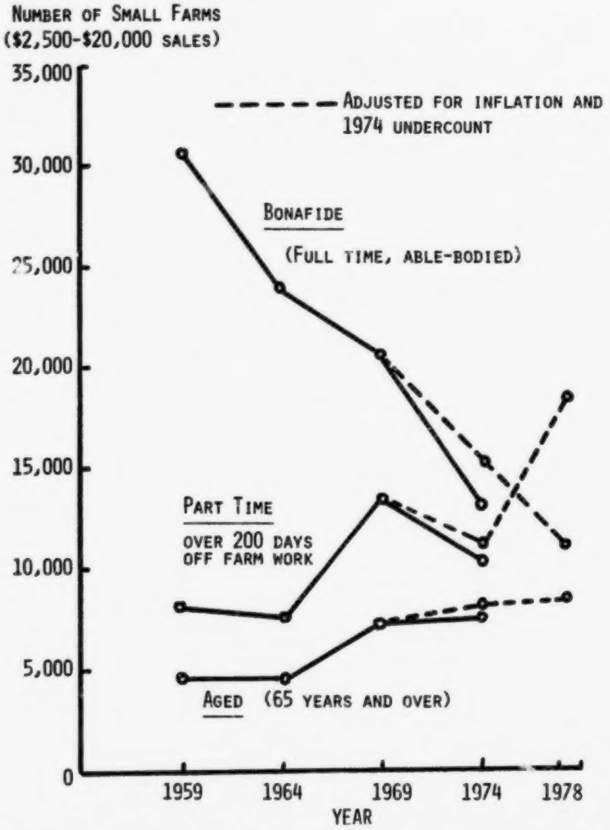

Figure 1. Trends in Small Farms in Oklahoma, 1959-78
Source: Basic Data from Census of Agriculture (20).

Economic Characteristics of U.S. Small Farms

U.S. data for 1975 (2, p. 936) revealed that farms with gross sales under $20,000 as compared to all farms had on the average a higher proportion of operators working 100 or more days off the farm (55% versus 35%) but, unexpectedly, lower median off-farm income ($3,800 versus $7,400), higher incidence of operators over 65 years of age (22% versus 15%), fewer acres per farm (82 versus 185), fewer assets ($91,000 versus $232,000), less net worth ($84,000 versus $204,000) and less total median income from all sources ($6,200 versus $10,300). Enterprise selection was similar for small farms and all farms with emphasis on livestock (including dairy), corn/soybeans, and small grains. A notable exception is horticulture farms which accounted for a higher proportion of small farms (26%) than of all farms (7%). Census of Agriculture data for 1974 reported by Tweeten and Huffman (19, p. 51) also show striking similarity in enterprises among farm sizes.

Differences in assets($1,254 per acre on all farms compared to $1,110 per acre on small farms) reported for 1975 by Carlin-Crecink (2) are not substantive. More notable is that small farmers leverage their net worth through use of credit less than other farmers: The ratio of debt to assets on all farms is nearly double the ratio on small farms (19, p. 29). Of course, differences in economic characteristics such as those above would be more pronounced if small farms were compared with just large farms rather than with all farms. Small farms account for nearly two-thirds of all farms but for less than 10% of farm output. It is important to note that the rapidly changing composition of small farms apparent in figure 1 is rapidly altering economic comparisons between small and large farms.

Economies of Size and the Paradox of Increasing Numbers of Small-Scale Farms

Massive evidence that small farms produce and market less efficiently than large farms explained the huge downtrend in small farm numbers prior to 1974 but not the uptrend since 1974. The data are reviewed below before resolving the paradox.

Evidence that small farms produce less efficiently than large farms is apparent for use of individual inputs such as energy, machinery and labor as well as for aggregate production inputs taken as a whole. According to unpublished data compiled by David Holland (Department of Agricultural Economics, University of Washington, Pullman) from the 1974 Census of Agriculture, very large farms (sales of over $500,000) used 6 cents of energy per dollar of sales and very small farms (sales of $2,500 to $4,999) used 24 cents of energy per dollar of farm sales. All classes of farms between these size extremes displayed a consistent pattern of higher energy use per dollar of sales for smaller farms. The data measured energy contained in commercial fertilizer, weedicides, pesticides and petroleum fuel for the farm business. If nonbusiness consumption of fuel for household transportation would have been included, the comparative disadvantage of small farms would have been even greater. Because of the high capital-intensity of equipment to extract energy efficiently from farm feedstocks to fuel farm machines (if rising real energy prices call for such drastic action), sharply rising real energy prices could further disadvantage small farms relative to large farms.

Machinery inputs also are used less efficiently on small farms than on large farms. Hall and LeVeen (6, p. 595) report for California that machinery values per acre ran two to four times greater on small farms than on large farms while gross sales per acre on small farms were less than half those on large farms.2/

The most controversial issue in measuring economies of farm size is how to handle labor cost. Some early "engineering" studies of size economies assumed operator-family labor fixed to the farm at its full-time opportunity cost in nonfarm employment (now about $20,000 per year). By this accounting, a typical family farm of today with sales of $20,000 would require all receipts to cover labor costs alone, leaving nothing to pay for land and capital.

An economic farming unit in 1980 that utilized the full-time annual equivalent labor of the operator and provided a labor-management income comparable to U.S. median family income required assets of $1.3 million and sales of $146,000 or more in the case of corn and soybeans in the U.S.3/ Sales requirements were broadly similar for farms emphasizing other crops. All significant economies of size can be achieved on a family-type farming unit of the size indicated above (21, p. 59).

In 1980, the labor-management share of all farm receipts among major types of U.S. crop farms ranged from 12% for a cotton farm to 18% for a corn farm. In other words, it cost 12-18 cents of labor and management to produce a dollar of output on an economic size unit in 1980. Charging only for hours of operator-family labor required on the farm at the opportunity cost of such labor (adjusted for age, sex and education in terms of ability to earn nonfarm income), researchers (19, pp. 53-55) estimated that farms with sales of $5,000-$10,000 in 1970 used 36 cents of labor for each dollar of output. Farms with sales of $40,000 to $100,000 required only 11 cents of labor to produce a dollar of output in 1970.

The most appropriate measure of economic efficiency among sizes of farms is the ratio of aggregated inputs to aggregated outputs. Again numerous "engineering" studies (see 13) as well as studies of actual performance (19, p. 55) show that small farms produce less efficiently than large farms. Of course, a few small farms produce efficiently (cf. 6, p. 592; 12, p. 111). But these are exceptions: An efficiently operated corn farm with sales of $150,000 produces at a lower cost per unit of output than an efficiently operated corn farm with

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2/ Because Hall and LeVeen rely on 1974 Census of Agriculture data which report machine numbers and not value, it may be argued that they overestimate machinery use and inefficiency on small farms where machines are older and of lesser quality than on large farms. This bias may be offset by failure to account for greater costs for repairs and lack of timeliness in crop production on small farms.

3/ See Tweeten and Huffman (19, pp. 60, 61) for methodology, data sources and 1976 requirements for an economic unit by crop.

sales of $20,000. Although less is known of economies of marketing than of producing, again the weight of evidence is for economies of size. However, there is no evidence that huge, industrial farms can produce and market more efficiently than can a family farm with $150,000 in sales. Exceptions are especially apparent for farms producing and marketing fruits and vegetables for processing, fed cattle and sugar.

If small farms are less efficient than large farms when labor is valued at opportunity cost, how can small farms not only coexist with large farms but also increase in numbers? The answer once was that small farmers are trapped in agriculture by inadequate knowledge of alternatives. With knowledge of options more complete today, the answer lies in the low return required by part-time farm operators and their families for their farm labor, the high psychic value placed on farm living, availability of local nonfarm jobs, and special tax and public service benefits available on farms. The desire by people to live on the farm has long been a cherished part of the nation's agrarian heritage. But that preference could not be acted upon without the means to do so provided by rural industrial job development. Off-farm jobs substantially reduced farm operator-labor opportunity cost (by sharing labor time with off-farm employment) and provided cash flow to cover costs for living and farming. The latter allowed part-time farm families to enter and survive in farming while their farm labor hours earned even less than their opportunity cost.

Social-Psychological Attitudes and Goals of Small-Scale Farmers

The success of publicly supported research and extension directed at small farms sometimes has been disappointing, in part because of attitudes and other personal attributes of people operating small farms. A number of studies reviewed by Colette and Easley (4, pp. 5-16) indicated that, compared to operators of large farms, operators of small farms tend to have a larger family size, less formal education, greater age, lower incomes, fewer organization affiliations, and less social participation. Small farmers are characterized as individualistic, conservative, resistant to change, strong supporters of traditional rural values and tied to social systems based on kinship or friendship. Many small-farm operators appear to make management decisions that increase security and certainty of expectation rather than maximum profit.

Most of these results were from populations dominated by bonafide small farmers. The new small-farm sector dominated by part-time farmers will display personal characteristics similar to those of commercial farmers. These characteristics such as income from all sources, education, work ethic and outlook on life can be classified as middle class. Some attitudes will differ between commercial farmers and part-time small farmers, however.

Extension personnel can extend information to commercial farmers with the assumption that most desire to increase farm income, improve farming efficiency, and participate in meetings. That assumption often has less validity for part-time small farmers. Enlow et al. (5, p. 4) reported the results of personal interviews of 8,537 families operating small farms in Missouri. Thirty-five percent planned to expand farming operations, 47% planned to keep operations about the same and the remainder planned to do less farming, work more off the farm or retire from farming. Families expressing a desire to expand their farming operation were asked what changes they would like to make. The most frequent response was "keep more beef cows." Of interest is the high capital intensity and low labor intensity of this activity. None of the nine most frequent responses indicated a desire for greater labor intensity of farming as would be apparent in a change toward specialty enterprises such as fruits and vegetables. The most frequent reason given for failure to expand was lack of resources. It is interesting to note that the small farmers who desired to expand operations had the largest of the small farms and had the greatest incidence of operators and spouses who worked full time off the farm.

It is also notable that small-farm operators in Missouri specified as their "opinion leaders" primarily large farm operators who make their living from farming" (5, p. 18). A "trickle down" effect is apparent in that small farmers do not rely only on their peers for information about farming.

RESEARCH AND EXTENSION TO ASSIST SMALL-SCALE FARMS

Competing claims on time (especially of part-time farmers), inadequate schooling (especially among bonafide farmers), dependence on friends and relatives for information, operations too small to justify (at least in operators' minds) the cost of searching out ways to improve farming efficiency, all combine to suggest merits of the paraprofessional, one-on-one personal contact information delivery system to reach small-scale farms. This method allows information to be tailored to the diverse individual goals and resources which characterize small farms.

The potential to raise incomes of small farmers by paraprofessional and other nonconventional information delivery systems is well documented. Orden and Smith (14), using linear programming to determine optimal plans for small farms in Virginia, found that 16% of the farms earned greater income than their optimal plans, 22% were foregoing less than $1,000 income per year, 15% were foregoing from $1,000 to $2,000 income per year, 18% were foregoing $2,000 to $3,000 income per year, and 29% were foregoing more than $3,000 income per year. Low volume and lack of technical efficiency were factors underlying foregone income.

Based on 1977 data, Smith, Hall and Simon (17, p. 8) concluded that potential increases in income ranged from $2,000 to $7,000, a figure in line with estimates from earlier studies adjusted to 1977 dollars (cf. 7, 16). If the average annual cost of technical assistance is $220 per farm (1977 dollars) as incurred in the Missouri small farm program, the increasing income by only 7% of the potential income gain of $4,500 (mid-range of $2,000-$7,000) would result in a benefit-cost ratio equal to $315/$220 = 1.4. 4/ In addition, there would be substantial savings in public welfare costs from additional farm income. Other estimates of the payoff from intensive programs of assistance to small farms in Texas and Missouri indicate benefit-cost ratios up to 3.0.

The hog enterprise was the large money maker on most Missouri farms surveyed (5). However, with operating capital restricted to $3,000, hogs were eliminated from the optimal enterprise mix and the less labor-intensive beef-cow enterprise was expanded. This was the direction of actual changes on the small farms during 1974. The most frequent reason given for lack of expansion on farms was inadequate capital.

An extensive survey of county extension agents in the northeast U.S. reported by Kerr (9) confirmed findings reported earlier that small farms tend to emphasize the same labor-extensive grain and livestock enterprises found on large farms although small farms more than large farms stressed production of vegetables, berries, nuts, and fruits for the fresh market, and sheep and goats. In listing specific research needs of small farmers, county agents in the northeast stressed the importance of production, management and marketing. It appeared that many of the production information needs were similar to those of large farms. County agents indicated that small farm operators needed to devise ways to produce more efficiently the products desired most by consumers. Small farms according to Kerr need management help in planning high-value crop production, keeping records, evaluating financial and credit alternatives, and determining feasibility of part-time, off-farm work. Marketing needs included information about direct marketing, particularly for vegetables and fruits.

In the most comprehensive review of small-farm special assistance programs to date, Orden, Buccola and Edwards (15) analyzed 23 programs directed toward operators of small farms in 14 southern states. These programs, eminating from both 1862 and 1890 land grant institutions, employed over 250 paraprofessional and professional field workers and intensively assisted more than 5,000 farmer-participants annually.

Over 90% of the small-farm program field staff indicated that their primary responsibility in working intensively with farmers was on a one-to-one basis. Almost 60% of the paraprofessionals reported making over 40 farm visits per month. In addition to one-to-one contacts with paraprofessionals, farmer participants were involved in other programs: 23% attended meetings, 12% participated in a tour or related activity, and 26% participated in both meetings and other group activities.

Proportions of farmer participants receiving various types of program assistance were as follows: 68%, soil testing; 48%, improving crop production practices; 44%, improving livestock production practices; 43%, improving gardening and food production for home use; 17%, improving available markets; and 5.5%, increasing participation in social programs.

It is notable that relatively few farmers received guidance in adding new farm enterprises (13%), eliminating unprofitable ones (14%), or expanding enterprise size (14%). The field staff apparently did not press for abrupt changes in enterprises or scale of operation of participating farmers. Instead, the staff emphasized improving production of existing enterprises (15, p. 35). Responses of program leaders suggest the most important training topics for field workers were, in descending order of importance: agricultural production and management, farm record keeping, techniques for motivating farmers, and garden production and management.

Participants in small farm programs improved their annual farm sales revenue by an average of $1,169 during the period of their program association, usually two to four years. Considering that work loads averages 32 farmers per field worker, program staffs helped to generate farm sales revenue in excess of their salary and support costs, although this conclusion might not hold for net sales if full accounting were made for all costs to farmers. Few farmers expanded their production sufficiently to provide an adequate family living from farming alone. Only one-third of farms with sales of less than $5,000 per year experienced an increase in income of more than $1,000 in 1977. Orden et al. (15, p. 61) found that income gains were lowest for farmers with the least education, least initial resources, oldest ages and with off-farm work

Research and Extension for Small Farms in Perspective

Paraprofessional delivery systems are costly and resources will not stretch to all farms. Priorities must be set based on criteria such as benefit-cost ratios. Data indicate that benefit-cost ratios for paraprofessional programs are less than those for conventional information delivery systems made available to all farmers. This statement does not necessarily mean that conventional delivery systems

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4/ The assumption that technical assistance realizes only 7% of potential benefits derives from a study by West et al. (23) for Missouri. Based on optimal income with operating capital limited to $10,000, a sample of small farms in selected counties of Missouri in 1973 indicated participants in the assistance program provided by paraprofessionals realized only 18.6% of their potential farm sales and nonparticipants realized only 11.6% of their potential farm sales. Net gain from assistance was 18.6 - 11.6 = 7% of potential sales. It is apparent that much scope remains for further income gains.

can be expanded to reach small farms with a favorable ratio of benefits to costs.

Recent results from Huffman and McNulty (8, p. 27) reveal an average man-day of conventional agricultural extension open to all farms in smorgasbord tradition adds nearly $20,000 to farm income. Their results are based on a study of 363 relatively homogeneous corn belt counties in Illinois, Indiana, Iowa, and Minnesota using data from the 1969 and 1974 Censuses of Agriculture. The results may be baised upward by failure to exclude some of the effect of "extension" provided by input supply dealers and other private firms. After correction for this bias, benefit-cost ratios and rates of return would probably be much higher than those on programs for small-scale farms. Numerous estimates (3, p. 11) indicate payoffs per dollar of conventional public research and education for all farms considerably in excess of those reported earlier for small farms.

Research and extension for small-scale farms must respond to their changing composition. If the predominant part-time small farm of tomorrow utilizes labor as dear as that on commercial farms, much of the size-neutral research on increasing crop and livestock yields emphasized by land grant universities will apply to small farms (see 3). Land grant universities have helped to establish electronic marketing, cooperatives and other systems to assist small-scale producers market commodities. Where benefit-cost ratios warrant, emphasis needs to be focused on "appropriate" small-farm technology research. But because such a small portion of farm output is produced by small farms and because the social benefit-cost ratios are in most cases much larger by emphasizing farming technology ultimately to benefit consumers (low-income consumers especially benefit in relation to income), the bulk of public research and extension will focus on size-neutral technology for all farms to serve economic efficiency and equity. Federal funding increases will be needed to justify an adequate research and extension program for small farmers.

Research Needs and the Oklahoma Study

Several authors (11, 19, 22) have detailed broad research and extension needs for small farms. Rather than repeat the proposals by these authors, I briefly outline some economic research and extension underway in Oklahoma that may provide a frame of reference useful in other states.

The Oklahoma work with small farms entails three phases: (1) Inventory the existing farming situation by a comprehensive, personal interview survey; (2) develop appropriate strategies for alleviating small-scale farming problems based on the composition of farms found from the inventory and analytical tools such as budgets and linear programming, and (3) employ paraprofessional and other assistance to alleviate small farmers' problems inventoried in phase (1) and analyzed in phase (2).

This study of approximately 400 mostly small, part-time farms in east central Oklahoma utilizes a farm classification system for analyzing problems and setting program priorities. Recognizing that lack of funds for research and extension will continue to limit severely the use of paraprofessionals, farms are grouped as follows into categories that are somewhat homogeneous within classes in problems and services required and amenable for ranking among classes according to need for services:

Class	Farm sales per year
Rural residence	Less than $5,000
Small farms	$5,000 - $40,000
Family farms	$40,000 - $200,000
Large farms	More than $200,000

Each class is then divided into two subcategories: Farms with net income from all sources above and below the poverty threshold (or, alternatively, nonmetropolitan median income). Farms with net income in excess of the threshold are of low priority for paraprofessional programs because they are not needy or produce little farm output. Of course, all such farms have access to the cafeteria of research and extension traditionally provided farmers.

Low-income small farms and family farms next are subdivided into categories according to characteristics of the farm operator: Bonafide, part-time and aged as in figure 1. These in turn are subdivided into those who want to earn more income from farming and are interested in paraprofessional programs and those who want to earn more income from nonfarm activities.

The highest priority in paraprofessional programs is assistance for full-time, able-bodied, low-income, small farmers who want to earn more income from farming and wish to cooperate. Preliminary impressions from the survey are that comparatively few farmers fall in this category. The second priority may be to assist full-time, able-bodied, low-income family farmers (sales of $40,000-$200,000) who want to earn more income from farming. Many of these later farmers may upon close examination be excluded from intensive assistance because they have high wealth or only temporarily low income.

Part-time farmers who wish to earn more from farming receive lower priority for intensive assistance because they are likely to have limited time to spend either with paraprofessionals or farmwork; also, many are sufficiently educated and involved to seek out research and extension assistance in the conventional manner. If these operators and their families have low income, they often are most effectively assisted by work force programs to increase off-farm earnings.

SUMMARY AND CONCLUSIONS

The 1970's witnessed the transition of the small-farm sector from a seemingly uneconomic anachronism to a vigorous, growing, new sector. In fact, the transition is the realization of trends underway for decades culminating in the near demise of the once dominant low-income, low-wealth, low-educated, low-option, full-time, able-bodied farm operator

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and the rise of the part-time small farmer. The latter is frequently well endowed with income, human and material resources, and vocational options.

Selected implications of this report are summarized below.

(1) U.S. farming will be dominated by two groups by the year 2000: A few large farms producing most of the output and a large number of part-time small farms accounting for the majority of all farms. Squeezed in the transformation into smaller numbers and proportions of farm output is the moderate-size, full-time family farm. Growth in part-time small farms will nearly offset the decline in bonafide small and mid-size farms, tending to stabilize total farm numbers.

(2) Families will live on small farms not because they know of or have no alternatives but primarily because they prefer farming and rural residence as a way of life and have the off-farm income to finance that consumption preference.

(3) Small farms will seek labor-extensive rather than labor-intensive enterprises because operators' time will be limited.

(4) Part-time farmers will participate more than bonafide small farmers in conventional extension activities but will not be strong or frequent participants. Reasons for lack of enthusiasm will be competition for time, lack of need for additional income from farming, and inadequate scale to reap large benefits from information search. The reason will no longer be lack of education to understand recommendations, social isolation, working class tendencies to feel out of place in a middle class audience, traditional values that oppose change, and fear of attempting new ways that might jeopardize already meager income. Many will need information on elementary principles of farming because they will not have been raised on the farm.

(5) Small farms with part-time operators will not be very responsive to farming economic conditions. Returns from farming will have small impact on the economic circumstances of those who make most of their income from nonfarm sources. Income of the modal small farm now is influenced much more by what happens to the nonfarm economy than by what happens to the farm economy.

(6) Any sharp change in trends in figure 1 from the 1974-78 pattern toward more small farms will depend heavily on public policy and energy costs. If land-use provisions are adopted that discourage conversion of farmland to residential uses, if real energy costs rise sharply, and if full costs are charged for rural services that are now provided on concessional terms to farmers, the number of small farms will stabilize or decline. But whether they grow, stabilize or decline, the composition of those that remain will alter radically.

(7) Summarizing now the economics of small-scale farms, we note that in prior decades many small farms had resources that would earn more elsewhere. But major adjustments have occured and most small farmers probably see no substantial opportunity for preferred use of their resources. Large numbers of bonafide and retirement farmers have left the farm. Part-time operators are not highly inefficient when their returns are properly adjusted to reflect the value of farming as a way of life. Some bonafide small farmers, many of them young and recent entrants, are seeking an alternative life style which they pay for by low earnings which do not warrant supplementing with public subsidies.

Markets can work out most remaining economic adjustments of small scale farming to the benefit of farmers and society except for some market distortions, two of which are listed below.

One is that society is subsidizing small-farm residence by tax and service incentives. Examples include inducements for nonfarm residents to move to small farms to utilize federal income tax features available to farmers, and subsidies to high-cost schoolbus, road, mail, water, telephone, electrical and other rural services. Charging full costs for these services would reduce urban sprawl, encourage appropriate land use and induce small farmers (and others) to make decisions consistent with needs of the nation as a whole.

A second issue is the role of public education and research in meeting needs of the new small-farm sector. Because agricultural research and extension alone is not a very effective anti-poverty device and because the incidence of poverty among small farms is now approaching the same levels as found elsewhere, a case can be made for allocating special research and extension efforts to small farms only to the extent warranted by benefit-cost ratios. Additional funding for small-farm programs can have a favorable payoff in relation to costs, but the data to date indicate that it is neither economically equitable nor efficient to divert such funding from conventional research and extension. However, we would like to know more about payoffs at the margin for various types of programs.

Although numbers of low-income farmers have fallen drastically in real and relative terms, enough poverty remains on small farms to be of concern, with concentrations in Appalachia, Carolina Coastal Plains, Alabama Black Belt, Mississippi Delta, and Four Corners Regions. Poor small farmers may be assisted with public outreach that contains a battery of tools including human resource development programs and, of course, agricultural assistance. For some of the able-bodied, the best option is improved labor skills and a nonfarm job; for others it is a more productive small farm.

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EQUIPMENT FOLLOWS PRACTICE: THE PROCESS OF ADDRESSING THE FUTURE EQUIPMENT NEEDS OF SMALL FARMS

Samuel W. Smith [1]

ABSTRACT

The cultural practices of Caretaker Farm were studied to model the process for determining the future equipment needs of small farms. Even more than the large-scale farmer, the small-scale farmer can not always farm the way he wants to because of the inappropriateness in design and scale of essential equipment. In many instances, the farmer makes awkward and inefficient adaptations of existing equipment to avoid the all-too-common situation where the technology itself dictates the practice. A better process for designing and developing equipment is needed, based on close observation of farms that follow good husbandry and the conditions that favor and protect the soil-plant association. Once a set of compatible equipment is developed for small farms, farms all over the world will be able to practice a resource conserving, economical and self-sufficient agriculture.

Keywords: Agricultural engineers, agriculture, cover crops, crop rotation, cultural practices, equipment, farmers, fertility, green manure, legumes, natural processes, permanent beds, rotations, self-sufficient agriculture, small farms soil, soil-plant association, soil structure, sustainable agriculture.

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PREFACE

As I began to prepare this paper with the request "to address all aspects, including domestic and foreign, of the future equipment needs of small-scale farmers," I quickly found the effort was leading to an annotated shopping list of equipment needs of small farms around the world. Such a list, I thought, while helpful to manufacturers currently searching for new products, wouldn't be of lasting interest to readers. It would, I felt, be analogous to a fall preview of spring fashions - something of immediate interest and curiousity but stale and outdated by the end of the winter season.

What follows is not an abstract listing of disparate agricultural needs but rather an in-depth description of the cultural practices of Caretaker Farm and, hopefully, by extension, a new way of visualizing the farming process and the related but subordinate process of how future farm equipment might best be developed.

New farming practices are needed to prevent the long term decrease in organic matter in the soil, loss of structure and water infiltration capacity, and the consolidation of the soil by monocultures and wheel traffic. The deterioration of the health of the soil has led to a greater tillage effort with a responding loss of soil by the increased flow of run-off water from the puddled soils.

As Dr. Wesley Buchele, Iowa agricultural engineer, stated, ".....the farmer farms as his machinery systems allow him to farm." I agree. Consequently, I hope that some day all farmers will be allowed to farm in a way that meets the needs of the earth with less subservience to what the equipment market happens to be currently offering in their sales catalogues.

INTRODUCTION

Because tools and equipment should follow practice, future equipment needs do not exist until the practice has been developed. There only exist immediate needs. In regards to future needs, there is a fertile connection in the process between the evolution of cultural practices that occur on farms dedicated to good husbandry and the innovative equipment technology that may, with luck and the cooperation of agricultural engineers, emerge from that process. In other words, if the chemistry between the farmer with a feeling for cultural technique and soil husbandry and the agricultural engineer with similar traits plus the habit of paying frequent visits to working farms is right, equipment with authenticity and integrity will emerge.

This paper describes the evolutionary process of cultural technique on Caretaker Farm. What is written here is from a working farmer's perspective. The overall goal is to contribute to a better and more precise response to the needs of farmers all over the globe for equipment that will enable them to practice a resource-conserving, economical and self-sufficient agriculture.

This paper will hopefully strike a responsive cord in the attuned agriculturalist because it describes a farmer's (and, equally important, a worm's) perspective of what is good for the farm.

For the last ten years, I've approached questions regarding cultural technique and equipment from the standpoint of the fundamental conditions necessary for a sustainable and continuous cropping system on a small truck (vegetables and berries) farm. I asked what can I do to create a soil viroment for cultivated plants that is economical to sustain and that comes closest to the conditions that plants enjoy in their most healthy, natural, undisturbed environment?"

The fundamental conditions (1) are:

1. A soil that is always firm.
2. A soil in which passages created by roots, soil organisms and other natural causes are renewed and maintained.
3. A soil where there isn't a risk of waterlogging.
4. A soil that is always covered (preferably with something growing).

The practices I follow on my farm that come closest to maintaining the above conditions and that also insure a high level of production of market-quality crops include:

1. Permanent Beds. I follow a system for planting all crops including long-term, legume-based cover crops in permanent planting beds and keep all traffic off these areas throughout the year and even from season to season.

2. Shallow and Infrequent Cultivations. I persue every conceivable possibility for restricting tillage practices to the absolute minimum.

3. Maintaining a Soil Cover Throughout the Year. I maintain a permanent soil-plant association by keeping the soil covered at all times with either a cash crop, a short-term cover such as buckwheat, mustard or rye grass, a long-term cover of a grass/legume sod that;s fitted into a planned rotation, or a mulch.

4. Following a Long-Term (7-Year) Rotation. I follow a rotation which includes a minimum of three years in a grass/legume sod.

CARETAKER FARM

To relate these broad practices to a specific farming situation, it is important that I describe the farm I know best, my own Caretaker Farm.

Caretaker Farm is indeed a small farm comprising a total of 35 acres. This area includes a stream, some bogs, 5 acres of permanent pasture, 10 acres of steeply wooded hillside, and about 10 acres of tillable land. The tillable land is Sudbury fine sandy loam (Class II Agronomic Capability) and Warwick gravelly loam (Class III).

Eleven years ago all the tillable land on the farm was worn-out with little or no reserves of nutrients or organic matter. At best, it would support a poor stand of grass or a crop of unmarketable vegetables.

The first garden in 1970 was less than a half acre--all was dug and cultivated by hand. By 1975 I was cultivating an acre, but I still completely relied on hand tools except for the sparing use of a roto-tiller to lightly incorporate residues from winter cover crops into the soil surface.

I have gradually increased the cropping area since 1975. But I remain wedded to simple hand tools and labor-intensive methods. The reason behind my approach to equipment is less philosophical than it is to the fact that there are few implements, except the simplest hand tools, that are suitable to my practices.

A potentially big change came in the spring of 1980 when I began preparations for bringing some of my best land into production. This addition involved four and a half acres of flat meadow and increased my total production area to seven acres. This provided the flexibility for the full implementation of a 7- to 8-year rotation that will include a deep-rooted grass/legume sod and, ultimately, for beginning a long-term program of self-sufficiency and reducing the need for off-farm inputs.

But before I describe the 1980 and 1981 seasons at Caretaker Farm and the farm's long-term program for becoming self-sufficient, I will briefly trace the methods and practices that have evolved on the farm over the previous ten years.

I have developed a permanent bed system of farming. Every crop including long-term cover crops have been fitted to this system. It's a system that, while it employs some of the features known to many agriculturalists in connection with the use of beds, is somewhat unique to Caretaker Farm. It makes possible the goals of a practical system of self-sufficiency in fertility and a reduction in the scale of essential farm equipment.

The permanent bed system at Caretaker Farm has reached the stage in theory and practice where it illuminates unfulfilled future equipment needs. The permanent bed system begs for the timely application of the talents of inventive agricultural engineers. The engineer must design and develop equipment that will not only meet the immediate needs of the system--indeed some existing and readily available equipment can do that--but also enhances the special qualities and contributes to the development of the potential of this system of better husbandry.

A Detailed Description of the Caretaker Farm System

In terms of a permanent, protected, non-compacted, well-drained planting area, the beds are well-nigh ideal. The beds are 42 to 46 inches wide and vary from 20 to 250 yards long. The center of each bed is precisely 60 inches from the center of the next adjoining bed. Each bed is separated from its neighbor by a furrow or path 14 to 18 inches wide. All wheeled and foot traffic is limited to this path.

All the beds on the older two acres of cropland were built by hand. The process of making the beds is as follows: The old sod is broken by a spading fork or a conventional moldboard plow. The land is then disked, fertilized, and seeded to a quick-growing cover crop that's suited to competing well with the heartiest and most aggressive of weeds. Following the initial cover crop, the land is either formed into permanent beds or seeded to a deep-rooted mineral-extracting crop such as a mixture of grass and alfalfa. When the new land is finally ready, the beds are made by the following steps:

1. A taunt line is stretched along the border of the newly cultivated land.

2. A long-handled shovel is used to dig a shallow trench approximately 6 inches deep and 12 inches wide along the edge of the taunt line.

3. The soil from the trench is thrown onto the middle of the first bed.

4. The bed is raked smooth.

5. Succeeding beds are made the same way with the trenches and beds running parallel at 5 foot increments to the first bed unit.

After the beds are made, there's a strict injunction against any traffice over them or any cultural practices and implements on them that would adversely affect their structure or their integrity as a permanent home for succeeding soil-plant communities.

With permanent beds, this injunction is not difficult to follow. The goal, as the seasons and years pass, is to improve the physical qualities and environment of the beds as a site which can sustain a continuing diversity of plant and soil life and on which natural biological processes can freely operate. In simple, practical terms, this means:

1. Keeping something growing on the beds at all times to build organic matter and protect the soil from rapid changes in temperature and moisture.

2. Employing only shallow and infrequent cultivations to assure a firm and uniformly structured soil.

3. Protecting (again by keeping to shallow and infrequent cultivations and following a carefully planned crop rotation) the naturally formed cracks, openings, burrows and passages that run through the entire soil profile.

On my first garden eleven years ago, the initial weed-competitive ("cleaning") cover crop was always the preface to the construction of permanent beds and continuous vegetable cropping thereafter. But beginning last year, the cleaning crop has been the precursor of a grass/legume sod. This summer, for example, an acre and a half was seeded to a mixture of alfalfa and timothy around the middle of August while another two acres were seeded in late August to a mixture of rye and hairy vetch. Both seedings are on land that a few months earlier was in old, worn-out sod, the sod having been moldboard plowed in late May and seeded to buckwheat in early June.

There are exceptions or alternatives to the early inclusion in a rotation of a deep-rooting legume sod, but most of them involve a reliance on chemicals. And this ignores the long-term goal of working with natural biological processes (examples being the carbon and nitrogen cycles) instead of depending on practices based on off-farm inputs, whether in the form of chemicals or your neighbor's increasing valuable manure.

Now let's study the significance of permanent beds. My goal is to develop a system that, on the one hand, is more self-sufficient, and, on the other, best responds to the labor and equipment situation of the small truck farm. In pursuing this goal, I'm trying to develop a set of practices that come closest to creating on cultivated land the conditions that healthy plants enjoywhile growing in rich, undisturbed, natural habitats.

What is the relationship between these fundamental conditions and permanent beds? What, to be more specific, is the relationship as I perceive it through the workings of Caretaker Farm?

Condition I: A soil that is always firm, giving good anchorage and conducting water upward from the subsoil to some extent.

With permanent beds, the main impediment to the upward capillary movement of soil water--plowing, heavy and frequent cultivation or any other form of "open heart surgery-type tillage" (4) on the soil--is eliminated.

With permanent beds, a firm soil is preserved because the depth and frequency of cultivations is decreased. Moreover, because traffic of all forms (machine and human) is kept off the beds, there is no need to reestablish a proper seedbed and rootbed with complex tillage operations between each crop or each new planting season. One plows once to reduce the bulk density of the soil and then never plows again. Indeed, with permanent beds, a proper seedbed is assured without anything more than a shallow cultivation in spring or between succeeding crops.

With the firm, undisturbed soil of permanent beds, the soil warms quicker in the spring (as opposed to the loose-cultivated soil associated with conventional tillage operations and seedbed preparation). Indeed, it is only under these conditions that a soil will conduct heat from the surface to the lower areas where it is stored and gradually released overnight.

Condition II: A soil in which ready made passages for plant roots are always being renewed and maintained. These passages are lined with concentrated Plant Foods and with Ample Air and Moisture.

Because the permanent beds require less cultivation, existing soil passages are protected. These passages are renewed through the root channels developed by the planting of deep-rooting legumes in the crop rotation and the activity of soil organisms, provided the latter have an ample supply of food on or near the surface of the soil.

The increase and preservation of soil passages in the bed system helps to provide superior drainage and prevent waterlogging. This, too, makes for earlier plantings.

The preservation of passages, channels, cracks and other openings from the soil surface on down also assures good aeration. In other words, the soil easily breathes while remaining firm and relatively undisturbed. Good aeration, in turn, favors the activity of free-living, nitrogen-fixing bacteria. Naturally, these bacteria also require a food supply in the form of soil organic matter on or near the surface. When the permanent bed system provides a constant food supply through crop rotations and the conservative use of composts, these bacteria will supplement the nitrogen needs of growing crops.

Condition III: A soil where there isn't a risk of waterlogging in wet weather because the beds are raised and there isn't a plow pan or impervious layer.

The furrows between the beds provide drainage for excess water. Because the elevation of the beds is above the furrow, an hydraulic gradient is created that causes, even under continuous heavy rain, rapid drainage to the field capacity of the soil.

The system reduces to the absolute minimum any practices that might lead to panning by controlling traffic on the beds. Parenthetically, anything that can reduce the amount of time and energy required for tillage practices is a real economy. The permanent bed system does that. It's the best system there is for reducing cultivations and for avoiding panning or compacting crop land.

Condition IV: A soil that is always covered, either by growing plants or a surface litter, gives protection against rapid changes in temperature, moisture and the nutrient level.

Mulches, both living and dead, provides a cover that protects the bed from direct sunlight which might otherwise rapidly heat and dry the bed.

I sometimes find that mulching with dead matter is logistically difficult (this, of course, points to an authentic future equipment need) or creates a physical environment that encourages certain fungal organisms or other pest conditions detrimental to plants. The alternative is an appropriately spaced living mulch of plants. And uniformly spaced plants on beds provide a much fuller coverage of the soil than in other systems of cropping.

Beds help the farmer organize his farm for the purpose of maintaining a nearly unbroken soil-plant association and the most favorable environment possible for soil organisms. As the English agriculturalist, Lawrence Hills, says, "the most important principle is to organize your crops so that as soon as something comes out there is something else to lant or sow afterwards.(2) Under the permanent bed system, it is easier to follow that principle than under any other arrangement. Since the planting system is in blocks of beds rather than in long rows, crops are harvested block by block or in distinct units that can easily and quickly be replanted with another vegetable or a short-term, quick-growing cover such as buckwheat, sorgum-sudan grass, sunflowers, rape, or mustard.

When the beds are kept covered the breakdown of organic matter is more gradual and steady in the environment that is created within and by the beds. For example, economies in the decomposition of soil organic matter are brought about by the minimal cultivations necessary for weed control, maintaining adequate tilth, and preparing the seedbed.

In either a conventional or bed system, available nutrients are firmly tied up by the roots of living plants and are not readily leached by drainage water. But once the plants die, the available nutrients may be leached from the soil by drainage water. Nonetheless, with beds, since excess water flows overland on the bed to the furrow, less leaching of nutrients takes place even in the absence of a soil cover.

Completing the Virtues of the Permanent Bed System.

From the perspective of agricultural techniques, the permanent bed system comes closest to no-till farming without the potential long-term damage (from herbicides) to the soil-plant community associated with the latter. Indeed, the permanent bed system creates the most suitable biological environment possible for the soil-plant community under the necessarily artificial conditions imposed by all agricultural practices.

From a labor or mechanization standpoint, weed control is easily accomplished on permanent beds. In fact, the genesis of the system at Caretaker Farm was the need for an efficient means of weed control under labor-intensive conditions. But regardless of the size of the farm, all cultivations (whether by hand or machine) under the permanent bed system become much easier in the uncompacted soil of the bed. And, as time goes on, the conditions for simple, low-cost, non-chemical methods of weed control become better and better.

Since the permanent bed system leads to a real reduction in cultivations, both in terms of depth and frequency, harvested crops are much cleaner than under conventional growing conditions. Also, by limiting cultivations and maintaining the organic matter content of the soil through a legume/green manure based rotation, a type of soil is formed that does not easily splash.

The permanent bed system maximizes the efficient and productive use of hand labor. Stooping for culivation and harvesting is reduced because of the extra inches of height afforded by the beds over the paths.

The organization of the lad into beds also helps to integrate everyone working on the farm into the total farm system in that beds and cropping areas are synonomous and clearly discrete areas.

The care of the beds provides everyone--old hands and novices alike--with a special objective and sense of comfortable familiarity with the land. The farm is more than a lot of endless rows; it's a lot of endless beds. But beds, I've found, have more character than rows.

Finally, the permanent bed provides the farmer with a greater sense of accomplishment, satisfaction and stewardship because it maintains the soil in a condition that is most favorable for plant growth.

Cultural Practices at Caretaker Farm Comprise a System that Has Never Been Mechanized

The development of Caretaker Farm (the designing by trial and error of a permanent bed system and the persistent effort of keeping something growing on the land at all times) is an example of what a minority of farmers are doing all over the country to expand upon the current store of knowledge as to what constitutes good husbandry and a sustainable agriculture.

But it is in the nature of things for agricultural innovation to be frustrated by the inherent limitations of existing equipment. And it is only the individual innovator (and not his or her neighbor) who will attempt, for the time being, to make do with what is available from equipment manufacturers.

On Caretaker Farm, I have managed with the following inventory of mostly hand tools:

2 long-handled shovels for forming the furrows (paths) between the beds.

2 heavy iron rakes for smoothing beds.

2 long-handled potato forts for use in the repair of beds, for incorporating soil amendments and for occasional secondary tillage purposes.

1 dibble stick (a sharpened broom handle) for making holes for transplants.

1 5" hoe for making wide, flat seed furrows.

1 warren hoe for seed furrows and V-shaped transplant trenches.

3 scuffle or hula hoes for cultivation.

36" water fillable lawn roller to form a firm seedbed after broadcasting and lightly raking in fine grass or legume seed.

2 wooden boards (1"x6"x14') for providing a straight line and accurate row spacing on the bed when seeding and transplanting.

Some scythes for mowing cover crops.

A rototiller for incorporating green manures and crop residues.

2 large wheelbarrows or hand-drawn carts.

1 hand-cranked broadcast seeder.

Caretaker Farm now has seven acres under a crop rotation. The bed system remains exactly as it was when the gardens were smaller, but the equipments for the present and future have changed.

Below is the new list of equipment currently available from dealers and catalogues to complement the original inventory, all of which remains necessary and appropriate:

25-40 hp tractor.

5 foot cultipacker seeder for cover crops.

2 middle buster shovels or two 10-12" furrow openers set five feet apart on a tool bar for building beds.

1 heavy duty rotary cutter or a heavy duty flail mower. Both machines for mowing cover crops. The flail mower can also be used as a forager in the process of collecting hay or mulching material. Both machines should be adaptable to cutting right down to the soil surface so as to leave the least amount of stubble and thereby reduce the possibilities for regrowth.

1 five foot, heavy-duty disk harrow with a combination of plain and cut-out blades. In the permanent bed system, the disk harrow becomes the primary tillage tool (plows, rotovators and other forms of primary tillage equipment should not be necessary).

Front end loader for tractor.

1 ton dump cart or small, PTO-driven manure spreader.

Spring shank cultivator

3 precision seeders on a tool bar.

Mechanical transplanter.

Where and how does this additional equipment fit into the farming system at Caretaker Farm?

Seven-Year Rotation at Caretaker Farm

The best way to answer the question is to summarize the seven-year rotation underway at the farm.

A study of the rotation, the use of equipment, and the melding of the rotation with the permanent bed system can begin at any point within the rotation. For the present purposes, I will describe the rotation as it runs through one field.

Year Zero

In mid-August of the current year--year "zero" in the rotation--the beds in the field were seeded to a mixture of 70% alfalfa and 30% timothy. The alfalfa/timothy sod will remain in place for roughly 33 months from the time of seeding.

The best available equipment for seeding the beds to a grass/legume sod without damaging their integrity is a five foot cultipacker seeder. Seeding the permanent furrows (paths) presents a problem because the rollers on the cultipacker are not able to make contact with the floor and sides of the furrow. The solution to this is to lightly rake the furrow after the seeder has passed and then make a second pass over the bed with the tractor alone so that the wheels of the tractor can firm in the seed that has fallen in the furrows. Alternatively, if adjoining beds are being seeded at the same time, the firming in of the seed in the furrow separating the beds will happen as a matter of course as the seeding operation moves from one bed to the next.

Year One

During year one, the sod is mowed at least twice for hay or mulch, or, alternatively, the cuttings can be allowed to just fall back in place.

Incidentally, if the cuttings are not removed, the vegetable farmer or the farmer that doesn't carry livestock should not be embarrassed. Indeed, as future research may demonstrate, rotting hay is better than manure for growing things, for the latter only contains what is left of the former after the cows have been nourished by it.

Year Two

Usually three mowings of the grass/legume sod are made in year two. The height of the mowing is important. The stand should not be clipped too close (about 9 to 12 inches is ideal) or else the maximum development of an extensive root system is inhibited.

As to mowing equipment, there is a need for agricultural engineers to develop new designs to fit the permanent bed system. In the meantime, five foot, heavy-duty rotary cutters will meet most of the cutting requirements for handling the various covers in the seven year rotation.

The significance of the deep-rooting, grass/legume sod in the rotation cannot be overestimated. Through the development of a deep and extensive root system, the foundation is laid for maintaining the structure and fertility of the beds. Moreover, it is through this phase in the seven year rotation that there is the greatest increase of essential nutrient elements added to the soil organic matter. This increment represents part of what can subsequently be cropped and carried off the farm without adversely affecting the balance of the soil or the status of the farm as a self-sufficient sustainable entity.

Year Three

In the mid-spring of year three, the field is cut one more time and then the beds within the field are disked to kill the sod. The amount and depth of the disking preceeding the next planting in the rotation can be significantly reduced if the sod stand is cut right at the soil level (the ideal here is to try to come as close to skinning the soil as possible) of the beds.

The next step is to reestablish the essential configurations of the permanent beds using two middle buster shovels (or two 10 to 12 inch furrow openers) set five feet apart on center or on the same spacing as the wheels of the tractor. After the sides of the beds and thepaths have been reformed by the shovels, the surface of the beds are smoothed with another light disking or raking.

Transplants can go in immediately following the above steps. However, if the bed is to be seeded with various vegetable crops, the beds are given a two week respite to allow for the decomposition of any residues that have been incorporated into the soil surface of the beds. This respite is also important to allow for the germination of any dormant weed seeds. The beds are then lightly disked again and the seedbed is ready.

Since most of the late-in, late-out vegetables are fitted into year three in the rotation, there isn't enough warm weather left in the season to obtain more than a mediocre catch on a winter cover crop seeding. Therefore, the farm's yearly production of compost is spread on the beds during the late fall. After spreading, the compost is lightly tilled in with a spring shank cultivator prior to leaving the beds in the field fallow over the winter.

Year Four

In year four, the beds in the field are ready for planting of all the extra early-in crops. Because of the previous fall practices, the field is in ideal condition for seeding or transplanting without any work other than, perhaps, a light raking of the bed surface.

Because of the extra early planting in year four, the harvest from the beds can be completed by late August, thus providing sufficient time for a good catch on a winter cover crop of wheat or other winter-hardy grain.

Equipment for sowing the wheat includes a hand cyclone seeder and disk harrow or, under favorable conditions that guarantee almost immediate germination, the cultipacker seeder alone.

Year Five

Since a clover will be sown by broadcast seeding into the winter wheat in late March of year five, the seeding rate on the wheat should be reduced by 25%. The lower seeding rate on the wheat will give the spring planted legume a better chance to become established and vigorously grow in the early spring.

A month or so after the clover is seeded and rolled with a cultipacker, the wheat will be cut in the boot stage as green chop, silage or mulch. Cutting the grain before maturity results in an even better establishment of the legume seeding.

During the remainder of year five, the clover — ideally sweet clover — will remain in place as a soil-building crop.

Year Six

In the spring of year six, the clover is cut down as low as possible to the soil surface. The beds are disked to kill the clover and, if necessary, reformed following the same practices used for going from a grass/legume sod to vegetables at a previous stage in the rotation.

The vegetable crops planted in the late spring of year six should be ones that can be harvested a few weeks before the first end-of-season frost. The beds are then cleaned with a light cultivation and raking and seeded to winter cover crop that is a mixture of rye and hairy vetch.

In order to create the optimal conditions for germination of late summer/early fall cover crop seedings, there's a premium on equipment and timeliness of operation. But with the good tilth and stable fertility of the permanent bed system, a farmer with appropriate seeding equipment is able to manage within the tightest of rotational schedules.

In the spring of year six, a problem could develop from the excessive release of nitrogen from the decomposing roots and plants of the one-year legume (clover) sod. This same problem could also arise at the beginning of year three when the rotation moves from a grass/legume sod into vegetables. The best way to avoid the problem and obtain the greatest benefit from the preceeding legume is to cut the legume plants right down to the soil surface and then remove most of the tops for mulch or compost on another part of the farm. The best equipment for this task would be a flail mower fitted with a rear delivery forage chute for delivery to a trailer. After the plant material on the beds has been cut and removed, the beds require only the lightest of diskings in preparation for the following vegetable crops.

By adhering to the above practices, the root network of the legume sod remains in place and undisturbed. The roots will thus decompose gradually and release stored nitrogen at a rate commensurate with the needs of the coming crop and create a balanced soil-plant economy within the bed.

The practices described above for handling green manures in the rotation complement and derive from the permanent bed system and offer an alternative to conventional methods that call for the full incorporation of green manure crops. Indeed, under conventional practices, the application of heavy tillage equipment appears necessary to achieve a rapid, but wasteful, decomposition of plant and root residues to allow for the creation of the kind of seedbed conditions to which farmers have become accustomed.

Year Seven

The last year in the rotation begins as early as the soil can be worked with a series of diskings of the rye/vetch cover crop planted the previous fall. The incorporation of the winter cover doesn't happen all at once; rather it proceeds at a rate commensurate with the need for space for a succession of early vegetable plantings.

Even with a non-legume cover such as rye, it's possible that an early incorporation of the crop when it is in an extremely young, green succulent stage can, as with the plow-down of a legume, create an excess release of nitrogen in the soil. Again the plant parts of the crop can be mowed at the soil surface and carried off, thus eliminating the need to mix the residues throughout the top soil layer.

There is a second alternative for handling the excess nitrogen that is often released and wasted under conventional tillage practices. Just prior to plowing down or rotovating the green manure crop, spread rough compost, straw or other highly carbonaceous material on the young, lush sod. This material, when tilled in with the sod, will provide extra carbon for the soil bacteria to work on and thus deter them, stimulated as they would be by the sudden infusion of excess air and nitrogen from normal tillage practices, from going after the reserves of soil humus for their energy needs.

Finally, there's a third alternative to a full scale plow down of a cover crop. This would be to simply mow the cover and then punch plant into the stubble. Experimentation in this method is required to check various stubble heights for weed control and different other effects. Such experimentation should include covering the stubble with sheets of black plastic and planting directly into the sheets.

As the final year in the rotation draws to a close, the cycle begins again with the reseeding of the field into a grass/legume sod.

The nice thing about the above seven-year rotation from both the perspective of greater self-sufficiency and quality crop production is that the farm is in a soil-building grass/legume or clover sod for roughly 45 out of 84 months or 54% of the length of the rotation. And yet the sod/green manure crops are only interrupting three out of seven arable crops. In addition, the deep rooting legume crops, while neither adding much to labor costs nor interfering with labor efficiency, more than pay their way as a basic contributor to maintaining the long-term security of the land and the farm.

ADDITIONAL DISCUSSION

Until the current stresses on the nation's soil and water resources precipitate a crisis or ecological catastrophe, and as long as there is a steady flow of off-farm resources entering through the farm gate, the conventional agricultural system will work. But it's a system that is vulnerable to interruptions in inputs; that is uneconomical because it fails to avail itself of many of the components of a balanced soil-plant economy that are freely supplied by natural processes; and that is not sustainable because of the accumulating evidence of its negative effects on soils and a healthy soil-plant association.

Once in place, a self-sufficient agriculture overcomes these weaknesses and is essentially invulnerable. The sobering fact is, however, that only a tiny percentage of the nation's farms have moved along the road to self-sufficiency.

Any for the rest, as witnessed by Caretaker Farm's work with permanent beds, crop rotations and often make-do adaptations of equipment, there is an awful lot of new practices to be learned and new equipment to be designed based on these improved practices.

SUMMARY:

"TOOLS, TECHNIQUES AND STATES OF MIND"

When men do work upon matter they employ tools which are of two kinds: physical tools of wood, bone, stone, metal; and psychological tools which are expressed in methods, and which become formalized as techniques;.....The psychological tools can be divided into two subclasses, the intellectual and the spiritual; the intellectual tools are concerned with method; the spiritual tools are concerned with relationships with the rest of the universe....A man uses all three kinds of tool to turn a piece of waste land into a farm.

An early problem which man had to solve was that of tree felling, and in course of time he evolved a perfect axe head. This tool was as good as it could be by late Neolithic times, and it remains unchanged in form....But the axe was only the physical tool which ancient man used to cut down trees, and the intellectual tool enabled him to devise the most effective way to swing his axe, to see where the tree should be cut in order that it should fall in a certain way. But what of the spiritual tool? It is this member of the trinity of tools which enables men to control and check their actions by reference to the "feeling" which they possess for the consequences of the changes they make in their environment. Man was anciently aware of the whole world as alive, and finding himself animated by spirit very properly supposed all other living creatures--and for him life was manifest even in stones--to be similarly animated.

This point of view is not one which we could adopt today, but it should be recognized that it was immensely valuable to the soil community and therefore, in the long run, to man.....No Agricultural Executive Committee, no Soil Conservation regulation could have been more effective. We use today the axe-head made by the earliest tree fellers, but not the spiritual tools of which they made use to regulate tree felling. What have we put in their place?"(3)

This paper calls for the implementation of something that is essentially new to the whole food system -- an effort to design and develop equipment for small farms. It also details the process or framework in which the design and development work should take place — that is it should grow out of a close examination of the best and most innovative practices taking place on a scattering of small farms all over the country.

Future equipment for both crop and livestock production should be designed with the intention of enabling farmers to reduce the cost of farming to themselves and to the land rather than simply providing them with a means of utilizing more and more costly off-farm inputs.

This implies a new direction for agriculturally related businesses -- one that might be less profitable for the producers and marketers of some agricultural inputs but more in the long-term interest of farmers and the nation's soil and water resources.

ADDENDUM: A BRIEF RECAPITULATION

The Caretaker Farm bed system provides for maintaining the four fundamental conditions for healthy plant growth. In addition, the following features and benefits are derived from the bed farming system.

A. Physical Conditions of the Soil

1. Beds warm up faster in spring and are warmer through the day.

2. Beds do not become waterlogged -- excess water drains from them to the furrow and well drained soils are warmer soils.

3. Beds are better aerated than flat land.

4. Nutrients are not leached from the bed by excess water.

5. Beds improve the capillary movement of soil water.

6. Since crops are continuously grown on the bed, the bed never consolidates from lack of root growth.

7. Tillage is not required to break up consolidated soil.

8. There is no traffice in the bed to compact the bed.

9. Continuous growing of cover increases organic matter of the soil.

10. The bulk density of the soil decreases.

11. The nutrient supply is slowly released from the decomposing organic matter and is immediately available for uptake by roots.

12. Bed farming promotes the growth of free-living, nitrogen-fixing bacteria by maintaining a food supply on or near the surface.

13. All root and earth worm channels are maintained in tact in the bed.

14. Residue and plant covered beds have higher populations of earth worms and soil bacteria.

15. Increasing the organic matter changes the color of the soil to a blacker soil.

16. Black soils are warmer soils.

B. Management of the Beds

1. Beds reduce time and energy required for primary and secondary tillage.

2. Workers stoop less when planting, weeding and harvesting beds.

3. Bed system maximizes the productivity of the labor force.

4. The labor force is easily managed on bed farming.

5. Beds are discrete areas for management purposes.

6. Records are kept by beds.

7. Beds look beautiful.

8. Since the use of beds eliminates three-fourths of the pedestrian paths between the rows, the width of rows can be reduced and productivity of the land maximized.

9. Bed farming can be used on any size farm.

10. High organic soils do not stick to root crops. Roots come out of the ground clean and ready for market.

11. Shoes and clothing stay clean while working residue-covered beds.

12. Soil splashing onto leaves of vegetables is reduced on residue-covered beds. There's less sand and dirt to be washed from the vegetables.

13. Highly organic, residue-covered soil can be planted, weeded and harvested while crops are wet.

14. Bed farming encourages timely planting, weed control, and harvesting.

C. Bed System Fitted Into Seven Year Rotation: Summary of Rotation

Year Zero: Field seeded to mixture of timothy and alfalfa to establish grass/legume sod.

Year One: Sod - Grass/legume mixture.

Year Two: Sod - Grass/legume mixture.

Year Three: Late spring till-in sod; plant vegetables including late harvested varieties; late fall incorporate manure/compost; leave field fallow until following spring.

Year Four: Very early spring plant hardy vegetables; late summer plant winter wheat.

Year Five: Very early spring broadcast clover; late spring cut wheat before maturity for mulch or haylage or, alternatively, allow to mature and harvest; for remainder of year clover nurtured to grow into vigorous sod.

Year Six: Mid-spring till-in clover sod; plant vegetables; late summer plant cover crop of vetch.

Year Seven: Early spring till-in vetch; plant vegatables; late summer reseed back to grass and legume mixture to begin rotation again.

D. Mechanization of Cultural Practices for Bed Farming (Unfulfilled Future Equipment Needs)

1. A self-propelled vehicle should be designed and developed for working within the guidelines of the bed farming system. Implements to be matched to the vehicle include the following:

2. Seeder that makes furrows of varying shapes in the bed, plants seed, covers the seed with weed-free soil carried in hopper on vehicle and waters the seed.

3. Spreader for laying fertilizer, manure, compost and mulch on the bed.

4. Heavy duty cutter that can mow vegetable plants and sod or cover crops to the precise level of the bed.

5. Mid- or belly-mounted cultivators.

6. Harvesting implement for cutting off vegetables from bed and transporting harvested crops.

7. Seeder for planting a wide diversity of grasses, legumes and other valuable forage and cover crops.

8. Bed former.

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CONCEPTS IN TECHNOLOGY TRANSFER FOR SMALL FARMS RESEARCH INTERNATIONALLY

J. K. McDermott[1]

ABSTRACT

Terminology currently used in agricultural research and extension in obsolete and clearly inadequate. This reflects in part the lack of conceptualization and the weakness of the concepts upon which we now depend and in part the traditional nature of the agricultural research and extension establishment. The problem is especially serious in international work and is becoming serious even within the tradition.

Keywords: Agricultural extension, agricultural research, farming systems, small farms, technology.

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Our "concepts" in dealing with the appointed subject are hopelessly inadequate, so inadequate, indeed, that they literally do not serve to give you a very secure expectation of what this paper is all about. As long as we were dealing domestically, we could limp along. Since most of us were nurtured in the womb of the Land-Grant College, we shared a common heritage, or common tradition. As we move onto the international scene, however, the conceptual inadequacies become almost fatal. Our traditionalism has almost done us in.

If I seem to be exaggerating the situation, it only betrays the enthusiasm with which I call attention to the problem.

Our problems start with the very words "research" and "extension." These are little more than *labels* in our system. The fact that we have two labels can be traced to a historical accident occasioned by a bureaucratic play to get more money into the state experiment stations. Up until 1909, state experiment station directors were using Hatch Act funds for publications and for work with farmers. That year, A.C. True of the USDA issued instructions that all charges for extension and printing be eliminated from Hatch Act funds. At the same time, he stated his appreciation for extension and pledged to do all in his power to get funds for extension. That he was sincere was evidenced by the fact that later in his career he was to head extension work in USDA.

Thus, what is essentially a single, integrated process was simply chopped in two. We labeled one segment "research" and the other segment "extension." We grafted over the wound by inventing so-called "extension specialist" with nothing more than slight interruption in our stride.

But when the system started to emigrate, our sins caught up with us. The labels simply had no power as concepts, even though we tried to use them as such. As someone said about the split season in major league baseball, "the situation is wrong, and the more you fuss with it the wronger it gets..." The problem is both (a) basic and (b) doubled headed.

Basically, the process of technology innovation (what research and extension is all about) is a single process. We can recognize the person who never gets off the experiment station or out of the laboratory as dealing in research. At the other end, we can recognize the county agent or field agent (who seldom gets on an experiment station or into a laboratory) as doing extension. There is a considerable segment in the middle in which we simply cannot distinguish research from extension. See diagram below.

The mischief caused by this "conceptual gap" in our our foreign assistance program has been considerable. We've done some fairly good work at helping to build capacity to deal with the ends of the technology innovation process. We have been clearly inadequate at addressing the mid-section. No matter how good the ends are, they don't add up to much if you cannot join them together.

We are trying to repair that damage now, as will be discussed later.

The situation becomes complicated by the fact that the farmer is also a researcher. Virtually no farmer will adopt a new technology without trying it himself or watching a neighbor try it. Fortunately, there is almost always one farmer who will try almost anything once. If it stands the test on his farm, then he will adopt it, and some of his neighbors will also. The extension demonstration is in many cases the final step in the technology generation segment of the process. The technology is still under test, the farmer's test, which is the stiffest.

The second head of the problem comes from our *not* distinguishing science from technology, in agriculture We simply throw them together in the bin labeled "research." This is more serious than mixing apples and oranges, which are at least fruits. It's more like mixing pears and pigs. Science is analytic. It abstracts. It controls all of the factors except the one under study. Science aims to give you a bit of information. That bit of information has no value *per se*. Technology synthesizes. This process is exactly opposite that of science. It puts together old technology, new bits of information, and even guesses to come up with a product that works. Science must control factors in the environment. Technology has to be fitted to the environment. It has to function in an uncontrolled environment. Our non-agricultural counterparts have avoided this mistake. They use the terminology "R and D," which distinguishes between "research" and technology "development." It's time that we did in agriculture.

SCIENCE		TECHNOLOGY					
Basic Research (Pure Theoretical)	Applied Research (Practical)	Development	Testing	Adaptation	Integration	Diffusion	Adoption

The Technology Research and Development Innovation Process

As long as we don't, the wrong situation gets wronger. In our frustration over the inadequacy of the term "research," we have coined a multitude of modifiers to help us talk with each other--such phrases as "adaptive research," "demonstration research," "test-bed research," "applied research," "basic research," "on-farm research," "farming systems research," and others. The problem with all of these coined phrases is that they have almost no value in communication. Each one of them means only what the user has in mind at the time he uses it.

"Technology transfer" is another one of those all-meaning, non-meaning terms. On some occasions it is a synonym for "extension." In my business, however, it can mean international transfer of technology, which puts it into a completely different context and for which at least one fairly sophisticated conceptualization has been worked out.

"Extension: has some inadequacies, even as a label. We need to think of "diffusion" of technology. However, "diffusion" and "extension" are not synonomous. "Extension" is really an administrative form, and in the United States this administration form has taken on a life of its own. At the same time, diffusion as a function is performed by many administrative forms or organizations--cooperatives, private industry, mass media, and credit institutions.

We've never developed a very useful concept of the "small farm." Howard Kerr came up with a definition in his survey, and it's interesting that two of his three factors have little to do with farming. One of them deals with off-farm work, and the other deals with total income. The total income level is the one that gives us the most problem. On the international scene, we are continually confusing farming with poverty when we get to dealing with the small farm. Howard Kerr recognizes the same issue, in his criterion of total family income of a "small farmer" being below the median non-metropolital income.

Internationally, we add another confusing element, namely, the confusion between the commercial and subsistence. There are some of us who are urging that the Agency needs to deal with the "small-farm, commercial" sub-sector of the agriculture sector. We hold that simply improving "subsistence" farming doesn't get us anywhere. We're trying to establish the criteria for commercial agriculture of selling at least half the production and of being in the market for inputs as well as for outputs. So far the definition has not caught on. We are consistent with Howard on one measure of size, using "family labor" as the criterion for "small," i.e., the family contributes at least one-half of the labor on the farm, but that definition likewise has not caught on in LDCs. That criterion will have a meaning in the LDC context, however, different from that in the U.S. context, chiefly because of the different structure of capital and labor between the United States and the LDC situation.

We are making some headway in filling in the segment of the technology innovation process. This is the conceptual gap I referred to earlier. However we are doing it without much help from our concepts. Perhaps in the pragmatic U.S. tradition, if we can make it work, then we can either develop our concepts or decide we do not need them. We have re-discovered "farming systems." That's what the agronomist, George Warren, discovered almost 60 years ago and from which he developed the farm management concept, which was to develop into a subject matter field and, in turn, was to figure in the creation of two professional disciplines, agricultural economics and rural sociology.

"Farming Systems" is another non-concept, and the trouble with its use as a label is that is is used for so many different types of activities. As far as concepts are concerned, this terminology may be jumping from the frying pan into the fire. Farming Systems Research — FSR, it's called — can mean either (a) R and D work which sets out to develop one or more systems of farming that can be alternatives to the systems currently being used, or (b) a modified form of conventional agricultural research that involves coming to terms with the current systems and of testing new technologies on the farms (or within the current systems) before recommendations are made.

The (b) meaning is instructive for us, especially for us in international work. After 20 years' absence from the domestic scene, I realize I don't know the domestic situation anymore. Any of you who are familiar with the rich Land-Grant tradition will recognize this meaning of "farming systems" as an old colleague. If you are not steeped in the tradition, you may find yourself also re-inventing the wheel. The "farm management survey" as an instrument is as old as I am (more than half a century), and its purpose was exactly to understand the farmer. The old "type of farming area" concept was virtually a farming system concept. The type of farming area was an area characterized by a predominant farming system.

In modern parlance, an area dominated by a common farming system is called a recommendation domain. A public agency dedicated to technology innovation must look for the commonness among farmers. None of us, certainly no LDC, can afford to treat each farm as a separate system, although there is always the tendency to try.

On-farm testing is not new. The result demonstration used to be one of the most popular extension methods. Perhaps it still is. Whether it was a test or a demonstration, we don't know. We called it a test if the person who did it drew his pay from the experiment station. We called it a demonstration if it was done by an extension worker. No matter, for the audience — i.e., the farmer, it was a test. And if it din't work out very well, it was also a test for those who put it on.

Why it is that we have had to re-invent the wheel? Many of us involved with international work were brought up in the Land-Grant tradition. Perhaps we are as traditional, or maybe even more so than the so-called traditional farmer we are trying to help out. Traditionalism is an interesting phenomenon. It leads one to behave in a certain manner (a) as his seniors did, (b) almost as if that is the only way, and (c) without questioning, either whether it's right or wrong or just what is it. Our Land-Grant tradition was rich. It was also complex. It was also a great institutional shelter for U.S. workers. Each could perform his function with neither an understanding of the tradition or a need even to worry about it. All he had to understand was his own role in it. Thus there was no pressure on us to conceptualize — to understand the tradition — to make it rational and objective. For this failure to conceptualize, we in international work have paid a high price.

I have been off the domestic scene for almost a quarter of a century. I don't know how well the Land-Grant traditions that I regard so highly, are serving you today. But as you, in a way, re-trace history to take another look at the small farmer, my intuition is that the use of labels for concepts may not be serving you much better than it is serving us.

UPDATE ON SMALL FARMS SURVEY IN THE NORTHEASTERN REGION

Howard W. Kerr, Jr.[1]

ABSTRACT

Once again and as indicated in a May 1979 study, small-scale agriculture in the Northeastern Region is in a transition which is expected to continue throughout this decade. Agricultural enterprises of small farms will change. At present, approximately 2 of 3 small farms are engaged in forage/livestock and 1 of 3 in horticultural enterprises. Expected in 1990 will be 56 percent of small farms engaged in forage/livestock, 39 percent in horticulture, and 5 percent in specialty crops. The number of small farms in the NER will continue to increase by about 8-10 percent by 1984 and by the same amount again by 1990. Growth will occur in 5 of 6 counties located in close proximity to populated areas and a 5 to 10 percent decline will occur in 1 of every 6 counties located in rural areas. Future priority areas for small farms research were identified as marketing and management. Research priorities for horticulture were strawberries, apples, sweet corn, tomatoes, and cole crops; for forage and livestock, beef cows and calves, sheep, and hay. A continuing need will be the close working relationship of Extension Service (ES) county agents and researchers.

Keywords: Agricultural enterprises, agriculture, economics, extension, family farms, farmers, northeastern region, research, small-scale farms, survey, technology.

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When one thinks of agriculture in the northeastern United States (NER) he or she may imagine herds of dairy cattle on lush valley pastures, or hillside orchards with ripening apples and peaches, or flat fields of yellow corn or small grains. This picture is partially correct, but not completely so, because agriculture is all of these and much more. This tranquil, still-life picture does not depict the living, changing industry that is agriculture today.

Small family farms are abundant in the northeastern United States, and the majority of family farms are engaged in either horticulture or forage/livestock enterprises. However, while these are the major enterprises, the family farms are diverse because of the region's great diversity in geography and topography; e.g., the tree-covered hills of Maine, the mountains of West Virginia and Pennsylvania; the coastal plains of New Jersey, and the low flat lands of Maryland's Eastern Shore. All of the northeastern states contain rural and urban centers interspaced among major metropolitan centers.

The Agricultural Research (AR) Northeastern Region (NER) is comprised of 12 states containing 298 counties, an area of over 200,000 square miles, and a population in excess of 55 million people. In aggregate, the region is an amalgamation of metropolitan and rural areas with various topographies and climates. The region's agriculture is varied, and both large and small farms are found in every state.

In colonial times, agriculture was the major enterprise of the region. Today, agriculture is no longer the major industry, but agriculture is very important to the region, both as an occupation for its inhabitants and as an industry needed by all. Oftentimes, it has been stated that the Northeast is more than 75 percent dependent on foodstuffs from outside of the area. In these times of spiraling inflation, high food costs, and other potential or unexpected threats such as the medfly, civil disobedience, contamination, etc., the stabilizing and fostering of an increased local food supply can become a crucial factor.

Farming in the NER is in transition. Techniques of production are changing, marketing procedures are shifting, and lifestyles of small farm families are continually being upgraded. It is difficult to keep abreast of all the changes. However, if NER small farm families are to be truly assisted by the Federal Government, their needs must be identified, and appropriate and fulfilling research programs, must be planned and enacted.

Knowing the specific research needs of small farm agriculture is the most important problem to solve. Despite limited funds and staff, and because small farm agriculture involves a wide range of diverse agricultural practices, identification of the answer is vital to all -- administrators, researchers, farmers, and consumers. Getting the answers is difficult and could not be accomplished singlehandedly. To assist us, I sought assistance from many sources -- key researchers located in the various NER State Agricultural Experiment Stations, scientists at private educational institutions, individuals in the private sector, and most vital, the cooperation of people in the Extension Service (ES).

To identify small farms needs and to plan appropriate research programs for the limited AR/NER research dollars and manpower, the NER in May 1979 opted for a survey of 70 selected cooperative county agents in the 12-state region. The various state directors of the Cooperative Extension Services identified the county agents for solicitation of the needed information. A 2-page questionnaire containing 11 questions, a memorandum explaining the purpose of the survey, and a definition of small farm operators was mailed to the participants. The definition was based on the following factors:

" -- Family net income from all sources (farm and nonfarm) is below the median nonmetropolitan income of the State.

-- The family is dependent on farming for a significant portion, though not necessarily a majority, of their income.

-- Family members provide most of the labor and management."

The information obtained was analyzed and a publication, ARR-NE-9 A Survey of Current and Expected Research Needs of Small Farms in the Northeastern Region, was published. Information in the report has assisted the NER Administration and management to maximize the allocation of limited research dollars earmarked by Congress to support small farms research. Most important, the information has proven useful for implementing immediate agricultural research and planning long-range technology.

While the above definition was widely employed by the Department prior to the current administration, the emphasis now is directed more to family farms. Nevertheless, because my research objective was to update the earlier study, I have utilized the aforementioned definition in the current study . The purpose of the updated study was to further refine the original study because of recognized dynamic changes in several sectors of our economy over the past 2-year period. Whereas the earlier study projected what may occur in the year 1984, the current study again looks at 1984, and in addition, at 1990.

In the original study, open-ended questions were used. All questions in the new study were structured so as to reflect the respondent's evaluation and rating in order of impact or importance relative to a specific topic about the operation of small farms or about members of families on small farms.

Seventy questionnaires were mailed to participants in March 1981. The participants were the same individuals screened in the first survey. Sixty-seven respondents completed and returned the questionnaire by July 1, 1981 and this information was used as the basis of the current study. Three questionnaires were not completed or not returned. One respondent indicated "there were no small farm families or farms in his county," and one respondent did not reply until after the July 1 deadline. None of the latter respondents had participated in the first study. Forty-eight of the 67 participating county agents had participated in the earlier study, and 19 were participating for the first time. As shown in the following data, 16 of the respondents had 5 years or less of service in the county for which they were reporting, 38 had 11 or more years, and the average was more than 14 years, as was the case in the former study.

SMALL FARM SURVEY 1981

Years	Respondents
5 or less	16
6 - 10	13
11 - 15	12
16 - 20	11
21 - 25	8
26 or more	7

AGRICULTURAL ENTERPRISES OF NER SMALL FARMS

Horticulture and forage/livestock are the major enterprises of NER small family farms. Each of these enterprises embraces a wide variety of particular commodities. In the most general terms, horticultural enterprises involve either vegetable or fruit and berry production, whereas forage/livestock enterprises involve dairying, beef, or sheep production.

Respondents were requested to estimate the percentage of small family farms in their county that were engaged in these two enterprises in 1981 and what they expected the percentage to be in 1984 and 1990. As shown in the following data, NER horticulture enterprises will substantially increase in the next 10 years at the expense of forage/livestock small farms:

Year	Horticulture	Forage/Livestock	Other
1981	30.38%	63.20%	6.42%
1984	34.13%	59.95%	5.93%
1990	38.63%	56.15%	5.22%

In 1981, two of every three (63 percent) of the small family farm operations in the NER were engaged in forage/livestock enterprises. In the western areas of the region, particularly in the Piedmont and Appalachian areas, small-scale farm operations were predominantly forage/livestock. However, a decline is expected in the number of small family farms engaged in forage/livestock in the future as small farms shift to horticulture or combine horticultural operations with their forage livestock enterprise. A substantial transition will occur during the 80's. By 1984, NER small farms engaged in forage/livestock will decline to 59 percent, and horticulture will gain more than 4 percent, to reach 34 percent; by 1990 forage/livestock will further decline to 56 percent and horticultural enterprises will increase to nearly 39 percent. Other enterprises in the NER, such as production of tobacco, maple sugar, cranberries, etc., will remain relatively constant throughout the 80's and will constitute about 5 percent of the enterprise mix.

The respondents listed several comments relating to why there will be a substantial shift in small farm enterprises during the next 10-year period. Less livestock will be produced due to the increasing cost of grain and the cost of producing livestock. The percentage of meat in the diet of many people is decreasing. As the price of land increases, small farmers will be forced to produce crops yielding higher returns and to produce fewer low value crops. Market outlets for locally-produced livestock -- beef, swine, and sheep -- are decreasing, and many small farm operators are experiencing difficulty in finding a place to market their production. Many of the respondents indicated that livestock enterprises will become less attractive as input costs continue to rise while returns to the operator remain relatively constant.

The anticipated shift to horticultural enterprises or combinations of horticulture with forage/livestock by some small farmers will be dictated by many factors. The climate and markets in the NER favor fruit and vegetable crops; less investment is required for these than is required for starting a livestock enterprise. The rapid expansion of farmer retail markets in all states within the NER encourages horticultural production In addition, there appear to be even greater opportunities for expanding horticultural production in most areas. Many small farm operations are restricted by small or limited acreage; therefore, they have little opportunity for a forage/livestock enterprise. Further, to afford and be able to acquire land (or more land) to become farmers, high value crops are necessary. The respondents indicated that retail vegetable operations are the most profitable small farms enterprise. One respondent indicated that "horticulture requires less work, less cost to establish and maintain, and requires only a few months work during the year. Conversely, people engaged in livestock are oftentimes tied down 24 hours per day, 7 days per week, 365 days per year. New people engaging in their first livestock enterprises quickly lose their enthusiasm, sometimes after only one or two years, and quickly get out of the livestock industry."

IMPORTANT AGRICULTURAL COMMODITIES

It is paramount that the very limited amount of funds allocated for small farms research be targeted to commodities that will benefit a maximum of NER small farm families. This task is not easy because small farms produce such a wide variety of commodities. To better understand the problem, lists of important commodities relative to the major enterprises, horticulture and forage/livestock were supplied to the respondents. For the years 1981, 1984, and 1990, respondents were asked to rate the commodities in each enterprise in order of importance to small farms in their particular county (Table 1).

Theoretically, those commodities that received the highest ratings should receive allocations of research dollars, as the research would have the most impact to benefit NER small family farms.

The commodities listed under each enterprise were rated by actual times reported by the respondents for each of the specified years. The weighted value was obtained by totaling the reported numerical values (1st = 9, 2nd = 8, and 3rd = 7, etc.) of commodities for each enterprise. Average weighted value of the commodity to the enterprise was ascertained by dividing the weighted value by the number of times the commodity was rated. The average weighted values may tend to be biased upward because not all respondents provided a complete breakdown into specific ratings.

Horticultural

The weighted average values of the various horticultural commodities were varied but were relatively close, particularly when compared in the three specified years. However, some horticultural commodities can be distinguished as more important to small farms than others. The most important horticultural commodity was strawberries, with an average weighted value 6.91 in 1981, 6.91 in 1984, and 6.84 in 1990. In 1981, sweet corn, with an average weighted value of 6.25, was the most important vegetable of small farms; in 1990 the value was almost identical, 6.27. Tomatoes were the second most important small farms vegetable. Apples were the most important tree fruit crop in 1981, 6.07, and in 1990, 5.97. The average weighted value of peaches in 1981 was 3.84; 1984, 4.64; and in 1990, 5.0. While the importance of this tree fruit is gaining, the actual numbers of counties producing the commodity are only about half the number compared to the number of counties producing apples or strawberries. In order of importance, the data indicate research dollars should be targeted relative to vegetables in the following order: sweet corn, tomatoes, and cole crops. For tree fruit and berries, emphasis should be on apples, strawberries, and blueberries. Also, there is small farm interest in production of greenhouse plants and ornamental nursery operations and in the future, more research should be targeted to these commodities.

Typical respondents' comments about horticultural commodities were as follows:

> "Vegetable crop production will grow at a tremendous rate in the coming years."
>
> "As food production costs rise, more emphasis should be put on horticultural crops that can produce more per acre of high nutritional value."
>
> "There is a growing interest in small fruit, particularly strawberries and vineyards. I see this trend continuing in the future years, also, all other small fruits should be very strong as small farm crops in future years."
>
> "Due to their growing season and the NER climatic conditions, small fruits, apples, sweet corn, and perhaps cole crops are the most important."
>
> "A keen interest in good marketing opportunities for small fruit production will greatly change this area from vegetables to a concentration of fruit and berry production."
>
> "Vegetables and small fruits have the best opportunity for retail sales and require less land investment."
>
> "Production techniques for greenhouse plants is of the highest priority, plus development of early-late and long season vegetable varieties to help extend the production time for NER crops."

Forage and Livestock

The average weighted values of the forage/livestock commodities were relatively close; however, declines of 0.1 percent or more of the average weight between 1981 and 1990 were noted for 4 commodities: dairy cattle, poultry, silage, and swine. Conversely, increases of more than 0.1 percent in the average weight rank were noted for goats and the category "other" commodities. Rabbits were the predominant commodity in the category "other".

For 1981, the average weighted value of 6.69 for dairy cattle was the highest rate of all forage/livestock commodities; however, the actual reported value, 48, was exceeded by 4 commodities; beef, cow/calves 58, average weighted value 6.09; sheep 57, average weighted value 6.00; pasture 57, average weighted value 5.37; and hay 56, average weighted 6.16. Of the three commodities relative to forage enterprises, hay was identified as the most important for NER small farms and for livestock enterprises, beef cows/calves and sheep.

Typical respondents' comments about forage/livestock commodities were as follows:

> "As these new small farm operators find out there is work connected with food production, they lose interest very rapidly and therefore the decreasing livestock and increasing vegetables, hay and pasture. Also, grain prices are $250/ton, up from $150/ton in the past few years."
>
> "No future--have to buy all the feed and can't compete with feed-growing areas."

Table 1.--Ratings by respondents of horticultural and livestock commodities for 3 years to establish priorities for NER small farms limited research dollars

Commodity	1981			1984			1990		
	Number of ratings	Weighted value	Average weighted value	Number of ratings	Weighted value	Average weighted value	Number of ratings	Weighted value	Average weighted value
Horticultural									
Apples--------------	42	255	6.07	39	236	6.05	38	227	5.97
Blueberries---------	33	173	5.24	34	187	5.50	33	177	5.38
Cole crops----------	27	129	4.78	24	125	5.21	24	129	5.38
Cranberries---------	5	5	1.00	3	5	1.67	3	8	2.67
Green beans---------	27	112	4.15	23	97	4.22	19	76	4.00
Greenhouse plants---	40	169	4.23	36	154	4.28	34	155	4.56
Ornamentals/nursery-	43	182	4.23	39	166	4.26	38	151	3.97
Peaches-------------	25	96	3.84	22	102	4.64	22	110	5.00
Raspberries---------	44	190	4.31	39	176	4.51	38	171	4.50
Root crops----------	33	147	4.45	26	121	4.65	27	121	4.48
Squash--------------	22	78	3.55	18	57	3.17	16	46	2.38
Strawberries--------	54	373	6.91	53	366	6.91	50	342	6.34
Sweet corn----------	57	356	6.25	53	326	6.15	48	301	6.27
Tomatoes------------	48	250	5.21	41	220	5.37	38	213	5.60
Vine Crops----------	36	163	4.53	32	158	4.94	31	146	4.71
Other1/-------------	12	71	5.92	11	85	7.73	11	85	7.73
Forage and livestock									
Beef cows and calves	58	353	6.09	55	329	5.98	53	322	6.08
Dairy cattle--------	48	321	6.69	47	311	6.62	44	288	6.55
Feeder calves-------	43	219	5.09	41	203	4.95	39	195	5.00
Goats---------------	35	164	4.69	36	171	4.75	35	177	5.06
Hay-----------------	36	345	6.16	56	352	6.29	52	315	6.06
Pasture-------------	57	306	5.37	53	292	5.51	51	276	5.41
Poultry-------------	44	196	4.45	43	184	4.28	39	167	4.28
Sheep---------------	57	342	6.00	55	337	6.13	57	345	6.05
Silage--------------	38	185	4.87	35	124	4.97	36	170	4.72
Swine---------------	46	248	5.39	44	229	5.20	41	213	5.20
Other2/-------------	18	106	5.89	18	110	6.11	18	118	6.56

1/ Includes grapes, maple sirup, and tobacco.
2/ Includes bees, cash grains, horses, and rabbits.

"Research on alternative feed rations using grains that can be grown in our area would be helpful. Again identification and development of markets in the area would also be of great assistance--especially for the swine industry."

"Smaller types of livestock appear to be the future trend, also, high cost of grain may lead to local grain production."

"More emphasis will be put on the animals that need little space to grow them and have a good feed conversion rate."

"Rabbits could develop as a major source of meat. Research on rabbits, sheep and veal seem important. Those are short term enterprises with limited over-head. Management and marketing research are needed."

"Rabbits and hogs are #1--very efficient producer of food; goats #2--producers of milk and meat on small acreages; sheep #3 -- already receiving plenty of research dollars and attention--but, it's worthwhile and much needed."

IMMEDIATE AND FUTURE RESEARCH PRIORITIES

In the first study, respondents were requested to list immediate research that might enhance small farms in their respective county. Their suggestions were categorized into 8 areas of research. Immediate research efforts to enhance NER small farms were identified as production, management, and marketing. Small farms with established commodity mixes and limited resources of land, capital, and labor needed appropriate research to enable increases in production. In addition, some small farm managers were sometimes identified as inadequate managers and consequently experience difficulty in adjusting to necessary new marketing methods.

The respondents were also requested to describe new technology that would enhance the small farms in their particular county in 1984. The suggestions received were again subjectively evaluated and categorized into the identified 8 areas of research. In order of importance, equipment, energy, production, marketing, and management were identified as the key areas of technology need.

For this study, the 8 areas of research were listed in alphabetical order and the respondents were requested to update the original assessments of the immediate and future research priorities for 3 years. Specifically, respondents were requested to rate the 8 research areas in order of importance (1 = high, etc.) to small farms in their county of responsibility (Table 2).

The ratings for each research area were weighted and the average weighted value for each research area identified for each of the three specified years. For 1981, marketing and management were each identified 66 times by the respondents, and the average weighted value of 6.02 for marketing was the highest of all the research areas; management, economics, and production followed in rank order of importance. For the year 1984, management, with an average weighted value of 6.02, ranked highest, followed by marketing, 5.92, economics 5.29, and energy 5.25. The respondents' ratings of important research areas for 1990 indicated management and marketing considerations will remain small farm operators' greatest need.

Contrary to the findings in the earlier study that identified equipment and energy research as high priority technology for 1984, the present survey failed to identify these research areas as high priority for future technology. An explanation of this occurrence was unavailable from comments obtained from the respondents. However, it has been noted and I have observed in various trade magazines information that indicates that during the past years availability of small-scale domestic and foreign tractors and accessory equipment has increased. Further, the unavailability of fuels encountered by small family farms in rural areas just two years ago has now disappeared. Perhaps these latter occurrences have dispensed from the respondents' minds the need at this time for future research in these areas. I'm not sure this will be the case next year or even tomorrow in these times of world turbulence.

Perhaps the comments of two ES county agents best summarize the immediate and future research priorities to assist small-scale agriculture--"good management is always the key to a successful farm operation and marketing procedures for small farms needs a lot of research," and "marketing is the key element today and will be in the future. Small farmers used to be able to market effectively, but at present, this is not easily done. For years marketing research has been much needed but unfortunately it has been ignored for some time."

EXPECTED CHANGE IN NER SMALL FARMS

Sixty-six of the 67 ES county agents estimated the percentage change (increase or decrease) in NER small farms in their county from 1981 to 1984 and 65 further estimated the percentage change by 1990. For 1984, 3 respondents indicated no change and 1 did not answer the question. Two did not respond for the year 1990 and 4 indicated there would be no change. For 1984, 53 respondents expected the numbers of small farms to increase and 10 to decrease. For 1990, 51 of 59 respondents thought NER small farms would further increase and again, 10 respondents expected the number of small farms to decrease. The ratio of 5:1 respondents anticipating an increase in both of the specified years is far greater than the 2:1 ratio indicated by respondents participating in the first study.

The earlier study estimated that 2 of 3 NER small farms would increase about 17 percent and 1 of 3 would decrease about 14 percent by 1984. The current data indicate that by 1984, 5 of every 6 NER counties can expect an 8-10 percent increase in the number of small farms in both 1984 and 1990 and conversely, 1 of 6 can expect a 5 percent decline by 1984 and a further decline of 8 percent by 1990. The declines will occur in counties located in remote areas and away from the metropolitan areas where gains will most likely occur (Table 3).

Typical respondents' comments relative to an expected increase in the number of NER small farms in the future were the following:

1984(+10%) "County location adjacent to metro area makes it attractive for people with full-time employment to own small farms and commute to a regular job. Population growth in county very rapid. Specialty crop farming well adapted to part-time operation."

1990(+15%) "Growing interest by small operators in fruit and vegetable production for pick-your-own operations, farmers' markets, and roadside sale. Retired people growing in numbers and looking for income source to supplement retirement income."

1984(+10%) "The amount of people interested in part-time farming has increased substantially in the last year. I believe there will be more of an increase due to higher costs of transportation and taxes on the land. The input - 70% of their food is resulting in people becoming more self-sufficient."

1990(+10%) "As food becomes more important cost-wise, there will be less imported into this state. Much land is not being used, but with higher costs, land is no longer sitting idle -- more people want to produce their own food and sell their excess amounts."

1984(+10%) "This area is close to metropolitan area and major highways. People can move out in the suburbs very nicely and commute to the city. Taxes -- if you farm--are lower. Therefore, we have many, many small farms."

1990(+15%) "Same as above--large farms are going out -- subdividing into mini-farms estates. High meat and vegetable costs are encouraging people to raise their own and to sell excess."

1984(+10%) "Division of larger farms and shift to horticultural activities instead of large animal agriculture."

1990(+05%) "Further subdivision of larger farms."

1984(+10%) "We are currently in a growth situation with this form of agriculture. Our increases have been a steady 10% in the last 3-4 years."

1990(+25%) "Food prices will be high and there will be a limited amount shipped to this state from the large growing areas of California and Florida. People will be forced to grow and market locally."

1984(+05%) "Will be an increased number of people having to find work in industry and other off farm work because farms too small to supply needed income. Some large holdings to be divided into small farms for such people."

1990(+10%) "Similar to above. Many people expected to want small farms to produce part of food and hold expenses while working off the farm."

Typical respondents' comments relative to an expected decrease in the number of NER small farms in the future were the following:

1984(-10%) "High interest rates, cost of production, and decrease anticipated in dairy price supports are not conducive to making a living on a small farm. I think they will eventually be absorbed by larger operations who have economies of scale."

1990(-25%) "It is thought the trend will continue on through the 90's as the 80's appear to be, unless action is taken to halt it."

1984(-5%) "We are a grazing area primarily for sheep and beef cattle. There is little opportunity for the small farmer to turn a profit on this sort of operation. Unless there are unforeseen changes in the economic picture the decreases could be even greater than I have estimated. There are a few people who believe there will be no livestock industry in this country by the turn of the century. If this is indeed the way things are going to happen, then there will be no small family farms either."

1990(-10%) "No comment."

1984(-10%) "When farm land is sold in this county it usually goes for non-farming purposes. Therefore, I see no other feasibility than a reduction of farm numbers."

1984(-25%) "Same."

1984(-10%) "Costs of farm inputs too high. Many will rent farm to neighbor."

1990(-12%) "Same as above."

1984(-03%) "For both '84 and '90 I believe at least two major factors will cause a decrease in small family farms as defined. First, with the ever decreasing average age of our farmers increasing, numbers will retire or be deceased and these lands will not be farmed by their children in great numbers. These farms will either be rented by others for farming, sold in many cases to non-residents for investment or utilized by U.S. Forest Service and go out of production. Second, if very low profitability continues,current farmers will be forced to seek larger portions of income from non-farm sources and probably reduce farming operations."

Table 2.--Ratings by respondents of research areas for 3 years to establish priorities for NER small farms limited research funds

	1981			1984			1990		
Research areas	Number of ratings	Weighted value	Average weighted value	Number of ratings	Weighted value	Average weighted value	Number of ratings	Weighted value	Average weighted value
Disease and pest control	64	296	4.63	59	271	4.59	56	248	4.43
Economics	61	326	5.34	58	307	5.29	56	297	5.30
Energy	61	274	4.49	59	310	5.25	57	302	5.30
Equipment	63	202	3.21	59	186	3.15	57	180	3.16
Management	66	386	5.85	63	379	6.02	60	356	5.93
Marketing	66	397	6.02	63	373	5.92	61	355	5.82
Production	62	326	5.26	58	287	4.95	55	279	5.07
Quality and preservation	51	110	2.16	47	105	2.23	46	104	2.26

Table 3.--Frequency distribution of respondents observations for 2 years to estimate the expected percentage change in NER small farms

Percentage Range 1/		1984			1990		
From	To	Frequency number	Percentage frequency	Cumulative percentage	Frequency number	Percentage frequency	Cumulative percentage
NC	NC	3	4.5	4.5	4	6.2	6.2
+01	+05	23	34.8	39.3	16	24.6	30.8
+06	+10	23	34.8	74.2	15	23.1	53.9
+11	+20	7	10.6	84.8	17	26.1	80.0
+21	+25	--	----	----	3	4.6	84.6
-01	-05	5	7.6	92.4	--	----	----
-06	-10	4	6.1	98.5	6	9.2	93.8
-11	-20	1	1.5	100.0	1	1.5	95.3
-21	-25	--	----	----	2	3.1	98.4
-26	-40	--	----	----	1	1.5	99.9
Total		66	----	----	65	---	----

1/ NC = No change

1990(-10%) "Same as above."

1984(-10%) "Increased costs--inflation, fuel and energy, labor, and net return decreases as market prices or products does not keep up with increase in production costs."

1990(-10%) "More of the above anticipated."

ISSUES AFFECTING NER SMALL FAMILY FARMS

Now and in the future, small family farm operations and family members will be confronted with issues that will affect the business and their lives. Lists are perhaps endless; however, to obtain some feeling of the magnitude and significance, a list of critical issues was established. The issues were the following: employment opportunities, fuel costs, interest rates, land price, Federal regulations, and State regulations. Respondents were requested to rate the critical issues, each in order of impact on the lives of family members and the success of the small family farms in their county. Respondents were requested to score each issue by 1 of 4 variables. They were as follows: 1, very critical; 2, critical; 3, less critical; and 4, not critical.

Fifty-five respondents gave 2,031 aggregate scores relative to the identified issues. The arithmetic mean was computed for each issue relative to family members and small farm operations for the 3 years of observation (Figure 1).

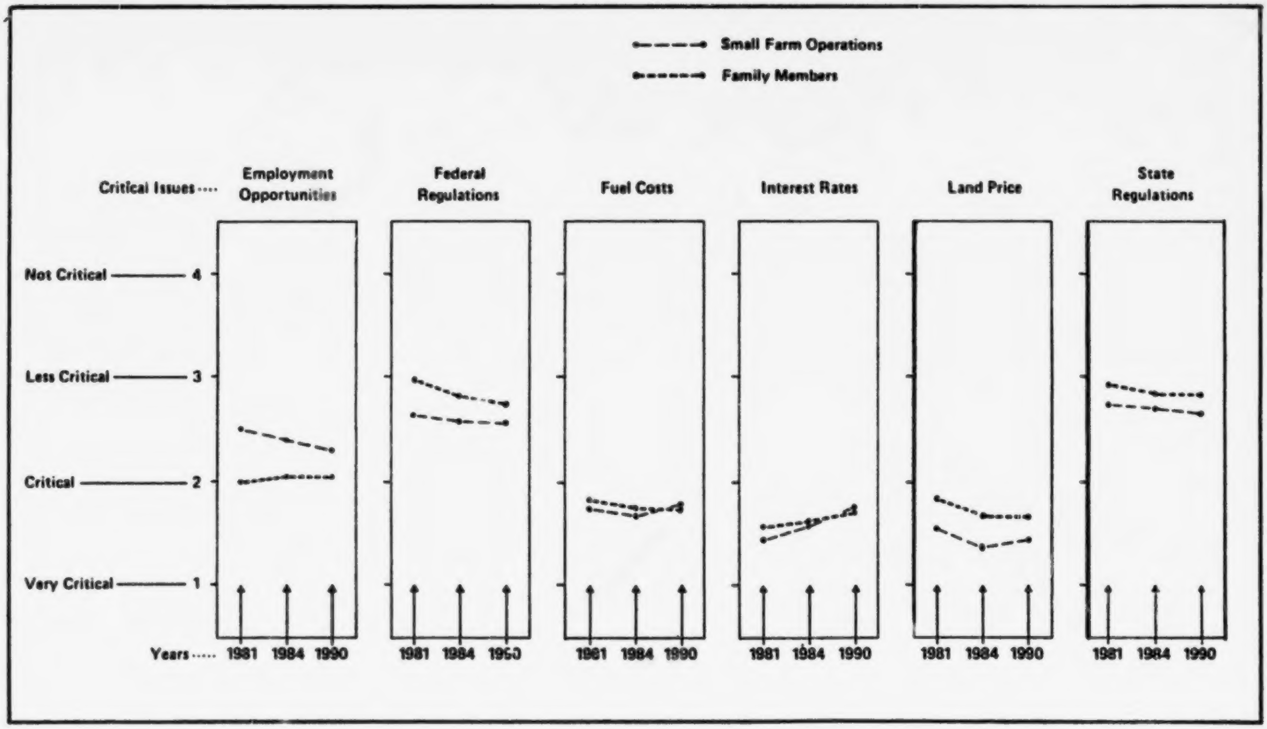

Figure 1. Critical issues affecting NER Small Farm Operations and Family Members

Federal regulations and State regulations were scored by the respondents as the least impacting on family members and small farm operations of all the identified issues. Small farm operations, however, will be more impacted by Federal and State regulations than the family members. Respondents offered several comments relative to Federal and State regulations as issues. "Farm land in estates must be passed on to sons and daughters involved in the farming operation without paying excessive taxes; present laws now are obsolete with rapid inflation." Another respondent indicated, "Most regulations are useless and unproductive, including pesticide regulations and enforcement harassment. Seems most government agencies (Federal and State) are anti-agriculture--EPA, OEO, Labor Department, Immigration, IRS, Water regulations, etc." Another said, "Federal and State regulations are more critical to large farming operations than they are to small family farms." One particular comment perhaps best identifies an underlying tone,--"probably all the issues will increase, becoming critical, unless we have less regulations--both State and Federal."

Fuel costs in 1981 were identified by the respondents as slightly more than critical and becoming more critical in 1984 for both family members and the small farm operations. Fuel costs for family members will intensify throughout the 80's. Although fuel costs are critical for the small farm operation respondents indicated that fuel costs as a critical issue would decrease after 1984. One respondent summarized the situation as, "I believe our people can learn how to beat high fuel and interest costs." Another said "in many cases these high costs will keep them from becoming overextended as so many of our small farm operators are now doing."

At present, interest rates are apparently more impacting on small farming operations than on the family members, but in the future, the reverse will occur. Interest rates will be more critical to family members than to the farming operation. Ratings of the respondents indicate that high interest rates now make entry into agriculture nearly impossible for young farmers, but the situation may ease or not be as critical in 1990. Other respondents commented that the cost of borrowing money and the lack of ready or available markets are the key factors as to whether or not small farm operations can survive. Similar to the earlier comment one respondent said, "high interest rates as well as high fuel costs perhaps keep all energetic farm families from overextending themselves as many small operators have done in the past."

Employment opportunities in 1981 were considered as more critical for family members than for the farming operations. For 1981, there was a wide gap between farm and family employment, and the gap is expected to continue through 1984 and into 1990. While employment opportunities for family members are expected to continue to remain critical and at a relatively constant level in the years 1984 and 1990 as compared to 1981, farm employment is expected to become more critical and even more severe in 1990. One respondent indicated that his county is changing from an area of losing population to one registering moderate gains. Population increases thus will be expected to put additional pressures on employment opportunities and the county's farmland prices. Also, some respondents indicated that off-the-farm work opportunities should improve in the late 80's and that increasing minimum wages are eliminating sources of farm labor in many areas of the northeast. Another respondent reported that in his county, nearly 50 percent of the labor force commutes out of the county to work. The latter indicates that jobs and job opportunities within many of the counties of the northeast are oftentimes scarce for rural residents.

Rising land prices were identified as the most critical issue facing farm families and small farm operators at present and in the future. By 1984, the issue of land costs will be nearing the very critical range for small farm operators in the NER. At present, farmland availability in some parts of the NER is almost non-existent for small family farm operators. Perhaps some relief is in sight as some respondents expect farmland prices to settle with the legislation of farm development rights being established in some states. By this occurrence the available land will then become limited and farm employment opportunities will become critical. Some areas of the Northeast, especially recreation areas are experiencing increases in population. The increase in population will not only put additional pressure on employment opportunities for rural residents, but also drive available land prices upward. Increasing land prices unquestionably will make land expansion difficult for small farms in the future. One respondent considered "foreign trade restrictions on agriculture exports as the negative factor in keeping farm prices down and hurting small farms the most." Another said, "most tax advantages given to farmers have drawn nonagriculture investors into agriculture, raising the price of land and creating more absentee landlords. "Another respondent gave specific examples of land values soaring in the past and implied that in the future we may continue to see land prices rise. Cited as an example were the escalating costs of a 20-acre orchard in his county. "In 1955 the cost was $8,000; in 1965, $18,000; in 1975, $50,000; and in 1981, the farm was $100,000." For 1984 and 1990 he just indicated a question mark. Perhaps this best describes the impact and importance of land prices on small family farm operations and to family members now and in the future.

TRANSITION IN SMALL-SCALE HORTICULTURAL ENTERPRISES

Sylvan H. Wittwer [1]

ABSTRACT

Small-scale horticultural enterprises are a component--perhaps the most important one--of small farms in the United States. All are labor intensive and characterized by high returns per unit land area. Issues of labor management and mechanization are paramount. There are strong international implications relative to the transitions in, and a research agenda for small-scale horticultural enterprises in the United States. The developing world, too, is affected, because it is a world of smallness.

Transitions relate to both production and marketing. They include the rise of roadside and on-farm markets, pick-your-own operations, increased sales outlets in city and small town markets, and other forms of direct buying and selling of horticultural commodities. New industries in the bedding plant and nursery business have developed and old ones revived, with a focus for success on specialized commodities, which are not attractive to large-scale growers but do have a program for direct consumer marketing.

The research agenda for small-scale horticultural enterprises must address the basic biological processes that control and limit not only total crop productivity but the dependability of productivity. Significant new biological developments in genetic engineering are occurring along with transitions in seed companies which will have impacts on the production of all horticultural crops. Meanwhile, there are applied problems relating to production and marketing systems, equipment, pest control, site assessment, financing, variety development, cultural practices, diversifications, sales, and concerns about regulations and farm labor that must be addressed.

Keywords: Cultural practices, direct consumer marketing, economics, equipment, financing, farm labor, Great Lakes, horticulture, The Northeast, production and marketing, pest control, small farms, small-scale horticulture, technological innovations, variety development.

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INTRODUCTION

A symposium such as this, which focuses on research for small farms, calls for special consideration of the transitions in small-scale horticultural enterprises. No farm type is more dominated by small-scale enterprises and diversities. Small-scale horticultural enterprises predominate among the small family farms in the United States. This is especially true in the Great Lakes and Northeast. In fact, vegetable production is the major small farm enterprise in 8 of the 12 states in the Northeast region (9). In no segment of American agriculture are the transitions more striking and the future more challenging than in such small-scale horticultural enterprises.

A small-scale horticultural enterprise has been defined for the purpose of this paper as one which:

a) has an annual income of at least $1,000 and an upper limit of $40,000 to $50,000;
b) may vary in size from less than an acre to as much as 40 to 50 acres;
c) is family-owned and operated;
d) deals with high value, specialized crops;
e) is generally labor- and resource-intensive; and
f) has a high cropping index.

Farms of this type will be covered in this paper. The segment of small-scale horticultural enterprises, however, that falls into the category of home gardens will not be handled, even though remarkable transitions are occurring. A Gallup Poll in 1979 showed that 42 percent of all households in the United States--33 million families--now raise vegetables. An estimated two million people gardened on community plots in 1978; and an additional six million said they would do it if they had access to land (24). Some innovative production methods (13) have been introduced for gardens, particularly for vegetables to increase productivity. All are labor intensive. Many European cities are now ringed by garden plots rented by city dwellers who bicycle to them during the long summer evenings and or weekends. In the USSR, there are as many as 50 million private plots on which an estimated 40 percent of all the potatoes--the most important food crop in the Soviet Union--are grown. The remarkable output of private garden plots in the People's Republic of China is having important impacts on the nation's economic policy where the percentage of land available in the People's Communes has recently been increased from 5 to 15 percent.

In addition to the definitive characteristics of small-scale horticultural enterprises listed above, most of these farms share certain other attributes, including the following qualities.

1. All are shaped by and depend on human labor.
2. They tend to yield high returns per unit land area.
3. High technology inputs common to these enterprises result in high quality products which remain fresh throughout shipping to markets.
4. Many--at least 60 percent--are operated by part-time farmers who have supplementary income from other sources.
5. Most have problems with equipment that is either outmoded, already used, inefficient in its use and conversion of energy, not fully adapted to small-scale farming or too expensive to be purchased, and not available when most needed.
6. Many farmers with small-scale enterprises find themselves caught in the controversy between mechanization and human labor; they epitomize the sociological issues that relate to growers and farm labor relations. One of the greatest deterrents to young people returning to or remaining on the farm after completing higher education relates to labor management and mechanization. In addition, there are accompanying unresolved migrant issues, such as housing and other economic, social, and political questions. Research that delves into the sociological problems of small-scale horticultural enterprises--their owners, operators, and laborers--is needed, along with studies of biological, physical, and economic issues.

The transitions in and research agenda for small-scale horticultural enterprises in the United States contain strong international implications. Fruits and vegetables contribute significantly to the food and nutrition of people in both agriculturally developing and industrialized nations. Their exact values, however, are not easily assessed, because, unlike grain, they are not typically items of international trade. In large part, they are locally produced, marketed, and consumed.

Yet there can be no question that the small farm is an economically viable unit. The world is full of such farms. The developing world, in particular, is a world of smallness (5, 18, 32) characterized by numerous small farms--tiny by comparison to large operations in America but similar in many ways to small-scale horticultural operations in the United States. These farms, while small in land and capital, require relatively large labor forces. Even in the United States, the majority of farms falls into the category of small-scale operations, and the current trend is toward even more small and part-time units. Moreover, the outputs per unit and capital inputs can be higher. Such labor-intensive operations may signal employment opportunities that previously have not been noticed, recognized, or taken advantage of.

Many new and foreseeable technological innovations to be discussed at this symposium are likely to find their place in the small-scale enterprise rather than on large farms. All nations--whether the United States, other industrialized nations, or the developing world--must direct serious attention toward production technologies that are scale neutral, nonpolluting, and environmentally benign, which will add to the resources of the earth, result in stable production at high levels, maximize output, optimize employment, and minimize resource inputs. Hopefully, this paper and other symposium contributions can fulfill some of these objectives.

The challenge of this symposium is to design a research agenda that will promote the productivity of small farms. At stake are the future welfare and economic viability of the many small farms throughout the United States, other industrialized nations, and the developing world.

Finally, each new technology, if it is adopted or useful to the developing agricultural world, must improve the economic condition of small farmers. Any research agenda for small-scale horticultural operations places a great responsibility on extension specialists to contact the many farmers who will be needed to put all new technology in place.

TRANSITIONS

Remarkable transitions (changes) have occurred during the past decade in horticultural enterprises--more so than in any other agricultural systems. They relate to increased numbers and diversification, the rise of new industries, changes in labor management and market outlets, resource inputs, and an increase in the use of chemicals.

The transitions that have occurred in small-scale horticultural enterprises could be classified into several categories: types of operations, marketing systems, production systems, and constraints on equipment and managing systems.

Likewise, issues that relate specifically to these kinds of operations include:

a) mechanization, labor, and attendant sociological problems,
b) the role and recognition of women,
c) toxic substances in the environment,
d) availability of resources, and
e) frequent high costs of local production as weighed against production and increasing transportation costs for produce from distant markets.

Many transitions in both production and marketing have occurred in small-scale horticultural enterprises during the past decade. They include the rise of roadside and on-farm markets, as well as pick-your-own or U-Pick operations. Renewed consumer interest in fresh produce has helped support the remarkable increase in the number, size and variety of city markets, people's produce markets, cooperative markets, and custom markets.

Further, there has been an increased interest by consumers and farmers during the past decade in direct buying and selling of farm products, particularly horticultural commodities. The passage of the Farmer-to-Consumer Direct Marketing Act of 1976 (P.L. 94-463) has facilitated the transition as has the elimination of the sales tax on food in many states. There is also a new recognition of quality by the consumer. The rise of activity in home gardening has contributed to that recognition. Per capita consumption of fresh fruits and vegetables in the United States is up from 1970. This is especially true for broccoli, lettuce, peppers, spinach and noncitrus fruits (27).

The results of a recent study (6) revealed about 15 percent (64,000) of the farmers in Indiana, Michigan, New Jersey, North Carolina, Ohio, and Pennsylvania sold about $260 million worth of farm products directly to consumers in 1978. Those direct sales represented 2 percent of the total farm income in the 6 states. The commodities that led in sales were all horticultural--floral and nursery products, apples, berries, peaches, sweet corn, tomatoes, and melons. Direct sales from the farm was most common followed by roadside stands. Other outlets were pick-your-own, farmers' markets, and roadside market operations, and house-to-house delivery. The pick-your-own and roadside market operations are now so numerous in Michigan with its more than 50 agricultural products--mostly horticultural--that a new directory is issued each year (12).

There are many market opportunities for small-scale fruit and vegetable growers. These were reviewed in a major symposium sponsored by the National Fertilizer and Development Center. Many direct market opportunities were highlighted in considerable detail including roadside markets, farmers' markets, pick-your-own marketing, pooling, and direct wholesale marketing (15).

There has also been a significant rise of new industries including ones like Michigan's bedding plant industry (fig. 1) which developed from a base of vegetable plant production for such crops as celery. These exemplify the transition from the production of vegetables to bedding plants and flowers in many of the greenhouse areas.

At the same time, the number of small fruit and vegetable processors has declined. Seed company ownership has changed, leaving such enterprises under the corporate umbrella of large pharmaceutical or chemical companies. While such transfers of ownership and management have advantages, they also can bring less-than-ideal changes. For example, seed may be less available to small horticultural enterprises, and seed companies may be less able to be flexible in filling orders.

Still other transitions have altered activities and attitudes among many small-scale horticultural enterprises. The trend of the past was to expand enterprises indefinitely, to get larger and larger--the "bigger is better" concept prevailed. More acres, however, have not necessarily maximized productivity. Instead, change has been prompted by limited resources--not only of land, but of water and other critical

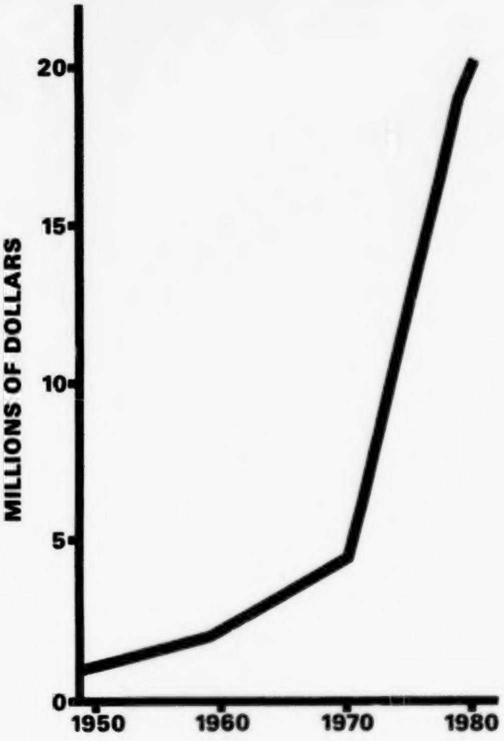

Figure 1. Growth of the Bedding Plant Industry in Michigan

resources. More productivity per unit land area is now the goal for many enterprises. And while acreage has not increased, output per acre has. Examples of this productivity are represented by strawberries without runners, hedgerows for stone fruit trees, dwarfing rootstocks and spur-type fruiting for apples, and increased labor-intensive operations such as the pruning of blueberries and raspberries for greater productivity.

In addition, there are many small nurseries which demonstrate the transition toward more and more container growing. This has meant a rapid turnover that improves cash flow--a problem which has been a real and harsh constraint in the nursery business. Improved cash flow reduces risk and is, therefore, desirable. The container production to realize this better cash flow, however, depends on irrigation with a readily available supply of high quality water.

Special reference is made to organic farms. They tend to be, but are not always, small-scale enterprises (see [26] for a definition). There are many diversified small-scale enterprises among them. The number of organic farmers in the United States is not known nor are transitions peculiar to them. It is believed by some that the increasing costs of chemical fertilizers, the constraints with the use of pesticides, and pollution hazards of natural waters with agricultural chemicals may be resulting in some shift toward less chemical-intensive farming systems (17, 26). The argument is that in the long term this would insure more stable, sustainable and profitable agricultural systems (10). It is not likely, however, that such a shift will occur with small-scale horticultural enterprises. Here enhancement of productivity per unit land area is a major objective. To do this will likely require more chemicals rather than fewer (2).

Special sociological, technological, and labor transitions are characteristic of many contemporary horticultural production units. Most are managed and owned by part-time farmers. Factory workers, seeking to supplement their incomes with crop production, work evenings and weekends. Producers may start with two or three acres and later expand to five and then ten or more. Many high school students and senior citizens respond to summer work opportunities provided by such enterprises. Yet vacations may be planned for the labor-intensive planting and harvest periods and may coincide with single-crop fruit and vegetable harvests lasting only two to four weeks.

Even so, small-scale horticultural enterprises have unique connections to and impact on successes in rural development. They provide work opportunities for the children as well as adults, including senior citizens and those who are unemployed or retire early. These job opportunities, in turn, offer additional income and the satisfaction of work to those who might not otherwise have them. Small-scale horticultural enterprises can give training to not only the children of a family but also to their friends. A unique employment and educational arena also is created; it brings the perspective of "hands-on" or field experience to the biology classes of primary and secondary school education. Economic training is provided to rural youth, in general. The size of each individual operation permits training of youth for future managerial positions.

One noticeable trend that may be associated with growing work and economic opportunities for rural youth is the increasing number of young people now moving into small-scale horticultural enterprises. The work involved is being viewed as a legitimate and honorable--even desirable--way to make a living.

In addition, this trend signals a good climate for the acceptance of new and progressive advances in research and technology, for it is frequently easier to teach the novice in a small-scale horticultural enterprise than a large-scale grower. Novices--themselves new--may be more attentive and responsive to innovations. The established grower, by contrast, might be reluctant to change, because success has already come from present or "conventional" technology. Beginners, who need not discard previous notions, may be more receptive to novel methods and ideas.

UNIQUE CHARACTERISTICS FOR SUCCESS OF SMALL-SCALE HORTICULTURAL ENTERPRISES

Corporate agriculture in the United States has not been successful (22). The continued survival of small-scale horticultural enterprises can aid the successful establishment of direct consumer marketing and the production of the numerous specialized commodities that are not attractive for production by large-scale growers. Such specialized commodities include unique house plants, bedding plants, sweet cherries for fresh market, cherry tomatoes, peppers, garlic, sweet corn, apricots, currants, blueberries, raspberries, cranberries, quince, ornamental squash and gourds, pumpkins, chile peppers, Jerusalem artichoke, Indian corn, health food store specialties, elderberries, French hybrid grapes with home wineries, Chinese fruits and vegetables including the Chinese pears, Chinese radish, and Chinese cabbage. Unique varieties or labels often make the operation successful. A good example is the Howell Honeyrock muskmelon grown in the vicinity of Howell, Michigan. Often there is the objective of meeting particular demands of ethnic communities and other special markets, such as Black, Chinese, Indian, Italian, Jewish, Southeastern European, and Mexican. Many profitable small-scale fruit enterprises have emerged, having been multiplied from what once was a single farm with hundreds of acres and thousands of trees to several individual farms with hundreds of trees on only a few acres. With apples, they are closely spaced, all on dwarfing rootstocks and with spur types of fruiting habits.

There are other unique characteristics, needs or requirements and trends for small-scale horticultural enterprises. For a pick-your-own operation, the customers do not have to be local. They will travel some distance and pay for good quality and freshness. Small enterprises are a source of high quality tree or vine ripened commodities. The greatest needs for all units are for extension, educational programs or applied problem-solving research to further adapt production technology to the small-scale horticultural enterprise. The changes in extension are often likely to be more extensive than those required in research. Traditionally, the trend has been for extension personnel to work with large farmers. This must be overcome.

In addition, special sales associations and cooperative selling should also be encouraged. Several farmers, each of whom, alone, can be only a small seller, would, if combined, have major market impacts. Cooperatives of small growers can sell big and gain greater control over their financial destiny. Shared time in the use of equipment also offers many opportunities for lowering production costs. This is essential, because doing a good job of production is not enough to insure survival; there has to be an adequate cash flow.

Creative use of agricultural by-products can help. There is great and untapped potential for the utilization of waste and by-products. Many small-scale horticultural enterprises are in proximity to urban areas that can become worthwhile markets.

There is a current shift toward locally grown commodities for fresh and processed food. Increasing transportation costs are a much bigger issue with fresh than processed fruits and vegetables. Energy for transportation is the constraint, especially for such major crops as apples and potatoes that are bulky. Yet these crops have a broad spectrum on environmental tolerance; they can be grown almost anywhere in the United States. Therefore, production is being brought closer to the consumer and can provide the stimulus for greater regional independence. Thus, the supporting infrastructure for small-scale enterprises is subject to change.

Small-scale horticultural operations need to be freed from the hindrance of unnecessary government regulations dealing with labor. These include unemployment compensation, workers' compensation, sick leaves and other leaves and absences, migrant housing, and social security payments. Small labor-intensive horticultural farms often cannot afford the costs that attend these regulations, and in frustration, some owners turn to employing illegal farm workers.

Even with these costs and constraints, small-scale horticultural enterprises are providing a partial resolution for a sagging economy. People can devote more time to such activities with current layoffs, earlier retirements, and shorter hours. The decline in numbers of migrant worker population is coupled with a developing symbiotic relationship between worker and grower. Migrants now are working with growers for mutual survival.

The sociological problems relative to migrant housing are real and have to be addressed. Are we using the most effective designs and programs? The social dimensions of limited-resource farming are complex, especially as they relate to migrant workers and their housing, health, and educational dilemmas. These difficulties are recognized in this report, but no agenda is proposed for their solution. No proposals can be advanced until adequate sociological research provides the data base needed to identify, isolate, and resolve these complex issues.

City and small town markets as sales outlets for small-scale horticultural enterprises are increasing in numbers and importance. This is a marked change from a decade ago. County extension personnel are bombarded with requests to develop produce markets in towns with 4,000 to 5,000 people or more. The objective is to attract business to small towns while providing local market outlets for small farmers. The numbers of direct marketing facilities are increasing (6). The key is a core of loyal producers who can provide a large variety of commodities, stability of production, and help in avoiding conflicts between growers, consumers, and sponsoring organizations. Profits can be especially attractive with fresh commodities of high quality, particularly for pick-your-own operations (table 1).

Table 1. Prices Paid by Consumers for Fresh Fruit Pick-Your-Own Operations in Eastern Michigan - 1981

Commodity	Price/lb. or Bushel
Strawberries (lb.)	55¢
Raspberries (lb.)	60-65¢
Cherries [Tart] (lb.)	70-80¢
Blueberries (lb.)	75¢
Peaches (bu.)	$13-14
Apples (bu.)	$7-8
Grapes (bu.)	$7-8

Apple production, as a model for small-scale horticultural operations, is both a challenge and opportunity. It provides a series of unique features. Apples are widely adapted and are dependable producers on many sites where other fruit crops would fail because of winter injury and early spring frosts. There has been more progress with crop management and fruiting types than for any other horticultural crop. Dwarfing rootstocks provide every degree of dwarfness and early fruiting. Cultivars will ripen over several weeks and even months in some locations. There are literally hundreds of strains or mutations of highly colored, attractive, and fruitful selections. Over 100 exist for Delicious alone (4). Spray schedules for insect and disease control have been made widely available, and there are opportunities for integrated pest management in which cultural practices and natural parasites play important roles. The key is early production and early return from a limited acreage.

TECHNOLOGICAL ISSUES

The growth and survival of small-scale horticultural enterprises are dependent on the cost and availability of equipment. Important issues about pest control and toxic substances in the environment must be resolved. The clearance of chemicals for minor uses is a continuing challenge along with the development of adapted cultivars. The survival of small-scale horticultural enterprises also relies on adequate research into the sociological problems tied to farm labor.

The United States Department of Agriculture, our host and sponsor for this Special Symposium on Research for Small Farms, and the State Agricultural Experiment Stations have been alert to these issues--perhaps not to the extent, however, desired by some (1). Yet, evidence for support of research on small farms is demonstrated not only in their sponsoring of this conference, but also in such publications as the 1978 Yearbook of Agriculture, "Living on a Few Acres" (25) and the recent "Report and Recommendations in Organic Farming" (26). To these reports can be added the paper "Research and the Family Farm" prepared by the Experiment Station Committee on Organization and Policy (3), and the recent report of a symposium sponsored by the American Society of Agronomy (28). All suggest a genuine commitment to establish a research and technology agenda for small-scale agricultural units.

Managers of small-scale horticultural enterprises generally are seeking and using the latest technological information. But the great differences among the people served, the large number of commodities produced, and the marketing options available to such enterprises typify the diversity of information needed by an audience with many and varied concerns. Practically, this often has meant that only some types of information could address all small-scale horticultural enterprises. Much of the current and applicable production research can be used by most enterprises but little research in mechanization, marketing, and utilization is applicable across the board. The overall effect often has been that much of the agricultural research conducted thus far has threatened--rather than supported--the survival of the small-scale operator (3). Meanwhile, much attention has been directed to informational and extension needs (21), along with social, economic, and non-technology considerations (7, 8). It is obvious that the special attributes of county extension agents and agricultural scientists must be combined to provide for the technological needs of the small-scale operator (9).

REQUIRED TECHNOLOGICAL TRANSITIONS

Many technological developments are applicable to the future success of small-scale horticultural enterprises. Their adoption must be encouraged. Included are the use of biodegradable plastic mulches for small fruits and vegetables; liquid or gel seeding; plug mix seeding and logistical problems in its use; conservation tillage; allelopathic responses of certain plant residues for mulches and for a partial substitute for chemical control of weeds; the production of adaptive and superior F_1 hybrid vegetable cultivars for improved quality, appearance, earliness, and productivity. New F_1 hybrids encompass carrots, onions, cucumbers, cabbage, sweet corn, squash, tomatoes, peppers, eggplant and asparagus. The development of cultivars that differ in maturity is needed to assure greater spread of the market season by individual crops. This holds true of many vegetables, cherries and apricots, and is essential especially among disease-resistant cultivars which are the most effective biologically controlled methods. There is a continuum of progress in protected cultivation techniques, drip irrigation, and slow release nitrogen fertilizers.

BEST DOCUMENT AVAILABLE

Tissue culture techniques are becoming increasingly important--even essential--for the propagation of disease-free clones of potatoes and for the maintenance of inbred lines for hybrid asparagus. For asparagus this technique avoids the inbred depression encountered through usual cultural methods.

GENERAL PLANT SCIENCE RESEARCH CONSIDERATIONS--PHILOSOPHICAL OVERVIEW

This conference was designed to focus primarily on research needs for small farms including small-scale horticultural enterprises. The future research agenda for farms of any size resides in biological improvement and in the management of resource inputs (31). Central is the control of basic biological processes that limit the productivity of all traditional and economically important crops, including those produced on small-scale horticultural enterprises.

To enhance future productivity and quality in those crops in both agriculturally developed and developing nations, biology, and more specifically, potential genetic improvements, must be advanced. Biological research that might enable all plants to utilize present environmental resources more effectively should be emphasized. Such research would likely focus on the following specific goals:

1. Greater photosynthetic efficiency.
2. Improved biological nitrogen fixation.
3. Genetic improvements utilizing new cell fusion techniques and haploid culture.
4. More efficient nutrient and water uptake and utilization.
5. Minimization of losses from nitrification and denitrification of nitrogen fertilizer applied in crop production.
6. Development of increased resistance to competing biological systems (weeds, insects, diseases, parasites, nematodes).
7. Alleviation of climatic and environmental stresses (unfavorable temperatures, soil moisture, and mineral stresses in problem soils).
8. Regulation of hormonal systems.

These objectives constitute the next generation of agricultural and food research (29). Benefits derived from research focused on any one or all of the above eight areas would be scale-neutral, that is appropriate for crops grown on farms of any size. Developing nations ought to be able to share the same comparative benefits and advantages as the United States in these research efforts. These frontiers of discovery are open to all. Advances made by one nation and shared by others can multiply the benefits of research many times (19, 20).

The governing principle should be high levels of crop production. Along with this, the stability or dependability of production must parallel the importance of production increases. Dependable crop production may be achieved by expanded irrigation of cultivated crops--both on dry land and under subhumid conditions--a goal admirably being achieved by the People's Republic of China. Quantum increases in future food production will not come from adding water to desert land, however. Only the use of supplemental irrigation in semihumid and humid regimes combined with the judicious use of pesticides and an expanded use of naturally produced and synthetic fertilizers will insure such dramatic and needed increases in food production and reserves.

In addition, improved pest control, reduced postharvest losses, advances in the use of protected environments for horticultural crops, and alleviation of climatic and environmental stresses will help stabilize and enhance the production of high quality products. Further, plants should be selected carefully and developed if they show superior characteristics of mineral metabolism that make them productive on nutrient-poor soils and under excesses of toxic elements and salts.

The effects of climate and weather remain the most significant determinants in horticultural crop production and account--more than any other inputs--for unstable and unreliable production and quality from year to year and in various locations in the United States. Improving resistance to climatic stresses through genetic improvement of crops and better management as designed and developed by substantial research studies would stimulate the growth and dependability of production and crop quality. With such developments, many areas now only marginal for small-scale horticultural enterprises could become dependable producing regions (23).

Biology and the potentials for genetic improvement can only help spur stable production and quality food supplies. We are now in the midst of the greatest biological revolution of all time--a renaissance in molecular biology brought on by the possibilities with recombinant DNA and the sequencing of genes. Genetic engineering has emerged during the past decade as a series of techniques of growing cells isolated in protoplast culture, anther culture and haploid production, protoplast fusion, and plasmid modification and transfer. So far the plants used have little or no food importance. There has been no success yet with legumes and cereal crops. Most of the excitement thus far has occurred in pharmacology with the bacterial synthesis of mammalian and human proteins (insulin, interferon, growth hormone), but these accomplishments in human physiology are providing a catalyst for work with food crops and food animals. For horticultural crops, collaborative efforts between plant cell biologists and plant breeders will have to occur. Meristem and shoot tip cultures are being used now for rapid multiplication of large numbers of genetically identical and uniform cut flower and potted plants. Meristem culture has also been employed with the potato for production of virus-free plants. Similar results have been achieved in producing disease-free plants of the African oil palm. Tissue culture techniques now appear essential for the future introduction of hybrid asparagus which can provide a remarkable leap in productivity (11).

Some future applications for genetic engineering in food crops will be the transfer of nitrogen fixation from prokaryotic species, bacteria, and blue-green algae to non-nitrogen fixers; the development of new hybrid plants; improvement of protein quality in crops; and the introduction of insect, disease, and herbicide resistance (16). Numerous vegetable, flower, and fruit crops respond to tissue culture techniques and clonal propagation.

Many large chemical corporations, seed companies, and newly formed biotechnology institutes are recruiting from academic institutions outstanding scientists with specialties in molecular biology, tissue culture, genetics, and plant breeding. The rapid rise of new biotechnolgoy companies has been referred to as "The Second Green Revolution." The future success of the new ventures in genetic engineering of plants will depend on active collaboration between plant breeders and molecular biologists. All the linkages that will be necessary to bridge the current efforts in molecular biology with those of crop production have not been identified, but the process has begun. There has been a literal transformation of American seed companies during the past three years in the United States. They no longer exist, as such, but have become integrated with or subsidiaries of large pharmaceutical and chemical companies (table 2).

Table 2. Transformations in American Vegetable Seed Companies

Past	Current Affiliation
Associated Seed Growers (Asgrow)	Upjohn
Burpee	ITT
Dessert	ARCO
Ferry Morse	Limagraim
Harris, Moran	Celanese
Keystone (Cornell), etc.	Agri-genetics
Northrup King, Rogers, etc.	Sandoz
Petoseed, Pieters-Wheeler	Ball

Important researchable needs relate to new cultivar developments. Specific cultivars must be developed to meet the various seasons of the year. Important in the north are melon and tomato cultivars to extend beyond the usual harvest season which ends with August. The northern tier of states needs cultivars that will extend the fall season. This means improved cold and chilling resistance in such crops as cucumbers, melons and tomatoes. For the southern tier of states it means heat resistance in the summer. For example, there are few fresh market tomatoes in the United States in June. This means that there are particular production and marketing problems in the mid-latitudes in the east and middle west where there is a very short spring.

One can anticipate, also, greater diversification in small-scale horticultural enterprises for the future. Increasing attention must be given to the potentials for intercropping and crop rotation.

Research for the future must also relate to alternating resource systems--land, water and energy and mechanization, resistance to and alleviation of environmental stresses, and competing biological systems. Pesticide resistance will need to be scrutinized along with toxic substances in the environment and toxic residues.

Postharvest and harvest losses must be addressed. Only a portion of many fresh market crops is harvested. The use of pregerminated seed for extending the growing season and shortening the time to produce a suitable transplant will become increasingly important. The need for cultivars evaluation will continue as well as the necessity of increasing productivity to improve the output per unit land area or resource input. The improvement of stand is a continuing challenge as well as uniformity of stand of direct seeded crops. This can be done by transplanting, but further efforts should be pursued with respect to direct seeding.

Relative to marketing, it is important to point out that no government subsidy or acreage allotments have ever been levied on horticultural crops. There have been, however, grower-initiated federal and state marketing orders that restrict acreage.

A fundamental area for research will be the nature of resistance to bacterial diseases such as fire blight and bacterial wilts. Important will be economic control measures. There is also a serious need and significance relative to pesticide application technology. More efficient applications of pesticides are necessary. This relates to the integrated pest management approach.

There are problems of air pollution. Small-scale horticultural operators are often near large industrial areas.

There is the issue of site specificities. This involves land planning and use and water availability and water use efficiency. There will be the continuing issue of people versus crops and when water is wasted, energy is likewise wasted. The importance of appropriate equipment relative to the small-scale horticultural enterprise will be a continuing issue.

There is a need for small-scale controlled atmosphere storage capabilities. Perhaps small compartments in larger units would be the answer.

Finally, there is the issue of management for small farms. This relates more to extension and research. Much research that is already done is scale neutral and applicable to small farms. In fact, most research itself is done on a small scale. Big farms in general have their own research programs, their repair shops, their technical advisors and consultants. It has been emphasized that size neutral output-increasing technology has contributed to making the U.S. the bread basket of the world--earn foreign exchange to pay for oil, and other imports and provide United States consumers with ample quantities of reasonably priced high quality food (30).

Economics of scale has not been given sufficient attention. The philosophy in the decade of the 1950's and 60's was to address large-scale agricultural enterprises. Small-scale enterprises can be economically sound, but we need to identify the ingredients that make them economically viable.

One phase of economics is related to equipment size. Machines, in general, have followed a need--a labor void--created as people left farms in hopes of finding a better life elsewhere. This labor deficiency dictated the move to mechanization and also renewed the emphasis on large-scale operations.

Current trends in farm size indicate that the numbers of both small and large enterprises are increasing while the numbers of intermediate farms decline. In addition, we are now also on the frontier of robotics. These trends pose an issue with respect to farm equipment research. Rather than having each person operate one large piece of equipment, an option for the future may be to have each operate several smaller ones. This might work around the clock with low power inputs. Currently small tractors and all support equipment are being advertised much more than in the past. Until now, most of our small tractors and support equipment have been coming from other countries.

Implement dealers in the United States are lagging behind in supplying the needs of small-scale horticultural enterprises. We are now witnessing, in the manufacture of farm equipment in the United States, a trend that could parallel the demise of the American automobile industry. Equipment produced domestically is too large and energy intensive for the small-scale horticultural enterprise. Small-scale horticultural enterprises will have to look at the possibilities and alternatives for energy self-sufficiency. Few manufacturers, if any, are producing tractors of 50 horsepower or less. Growers with small-scale horticultural enterprises invariably have to purchase imports or get by with oversized, energy-intensive, used machines.

The costs of this equipment is also a big issue. Cost or scale must come down. Manufacturers that can produce small equipment profitably need to be identified. It is very likely that high density orchards will start with small growers and not large.

Computer technology and telecommunications are going to play an increasingly important role in small-scale horticultural enterprises. We have entered an age of solid state electronics. Controllers, sensors, and microprocessors are now available. Likewise, remote sensing of environmental data and the more effective use of climate information in decision-making will become realities at the local user level (14). The data from environmental sensing will be transmitted by satellites.

Research management for small-scale horticultural enterprises poses important questions. Should each experiment station in every state be involved in research for all of the various types of small-scale horticultural units? Does regional research always have to be formalized? Cooperation between or among states can occur informally without the constraints of regional research project outlines and bureaucratic book work.

Regional efforts to spread among states the responsibilities of research development for small-scale horticultural enterprises are important. For example, research with fresh market tomatoes is currently conducted in Michigan, with the emphasis for processing in Ohio and Indiana. Informal arrangements can be effective. Grape research now occurs in Canada, New York, Ohio, and Michigan among an informal group that meets regularly to coordinate the effort. Opportunities for such informal arrangements are widespread.

The role of councils and commissions for support of such informal regional research will be essential in the future. Private consultants also are likely to be employed more frequently to help groups of small growers. Consultants will likely begin their work with integrated pest management systems. Growers may get together to pay an insect scout.

Further cooperative efforts among growers will be essential to insure the economic success, and even survival, of small-scale horticultural enterprises. Such actions could include cooperative buying and marketing, sharing in advisory services and hired labor, and in the use of equipment. Increased public support for research should be sought in view of the many remarkable transitions in technology that have occurred during the past decade and for those that are envisioned for the future.

SPECIFIC RESEARCH PRIORITIES AND NEEDS FOR PRODUCTION AND MARKETING

The recommendations which follow are for applied problem solving research efforts. (The numbering does not establish priority.) Many would fall under the category of demonstrations. Some of the more basic research initiatives are outlined under the previous heading--General Plant Science Research Considerations--Philosophical Overview. It is conceded that the priorities that follow for production and marketing research may be considered equally as important for extension. The best attributes and talents of both research scientists and extension personnel will have to be combined to achieve the objectives that follow.

1. Develop integrated energy efficient production and marketing systems that maximize production over a wide marketing period. Both high production and quality are essential.
2. Design flexible energy efficient tillage, cultural, harvest, and storage equipment. The challenge is to downsize and adapt. The approach is to use many equipment components as attachments on a main drive or power unit.
3. Seek new approaches for pest control. Integrated pest management systems will become essential for the survival of most small scale enterprises. These systems will need to insure the health and safety not only of the applicator but the proximal communities and consumers.
4. Provide guidelines for site assessments as to soil, water, climate, and human resources. These are important both for meeting production needs and the markets to be served.
5. Arrive at new and innovative schemes for financing, including long-term contracts. Interest rates and operational costs are rising precipitously. Long-term investments are necessary for fruit and nursery establishments.
6. Seek novel strategies for marketing, including vigorous individual and collective advertising through the public media. Commodity availability from unusual sources such as farm markets, pick-your-own, and community outlets should be emphasized.
7. Develop crop cultivars and accompanying cultural technology that will maximize productivity and extend the market season. There have been remarkable achievements with strawberries for year-around production in specific locations. Great progress has also been made with apples. Similar efforts should be extended to other crops.
8. Continue the expansion and use of resource-sparing technologies such as drip irrigation, conservation tillage, direct seeding, and allelopathic responses.
9. Design optimal strategies for crop diversification to spread labor, utilize resources and extend the cash flow. Identify the combinations of commodities and production patterns that will most effectively utilize the available labor and optimize income.
10. Improve the attractiveness of on-the-farm sales and pick-your-own operations. Seek the advantage of increasing consumer interest in the purchase of fresh fruits and vegetables as to tolerances of blemishes. Determine multiple uses of the same commodity for customers, and superior structures for laying out pick-your-own operations.
11. Improve social dimensions of small scale horticultural enterprises. Seek better methods of dealing with migrants and a resolution of their social and economic limitations and problems.
12. Look to other agriculturally developed and developing nations in Western Europe and the Far East (Japan, Taiwan, People's Republic of China) for new and possibly more appropriate technologies for intensified agriculture and small-scale enterprises. These technologies could include those associated with mechanization, crop varieties, waste and by-product utilization, green manuring and crop rotation, and methods of integrated pest management.

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COMBINING SEQUENTIAL CROPPING OF VEGETABLES AND MODERN CULTURAL PRACTICES TO MAXIMIZE LAND USE ON SMALL FARMS

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ABSTRACT

The appropriateness of vegetable crop production on small farms in the Northeastern U.S. is discussed. Research on ways to keep farm land continously productive and increase yields per acre is identified as needed in order to assist small farm operators who wish to maximize their profit. Specific studies that have been conducted include evaluation of several synthetic mulching materials and their effectiveness for vegetable culture, the interactions of various combinations of cultural practices and their practicality in combination with various cropping sequences, the value of degradable plastic mulches and the feasibility of polyethlene tunnels for extending the growing season. Preliminary results from the above studies are presented.

Keywords: Vegetables, cultural practices, mulches, sequential cropping, small farms

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Historically most, if not all, of the research conducted at Beltsville has been relevant to small farm production. However, during the last three years, many of us have been asked to focus more specifically on researchable problems unique to small farms. Because of my association with the Vegetable Laboratory and my interest in vegetable improvement and production, I naturally think first about how this group of crops fit into "small farm" production. Being located at the Beltsville Agricultural Research Center, I have focused my thinking on research to aid small farms in the Northeastern U.S. where the situation is somewhat different from other areas of the country.

Factors that I feel are important to keep in mind when thinking about research to aid "small farms" in this part of the country include the following. First, the northeastern states contain only 7 percent of the U.S. farms and approximately 3 percent of the farmland while in this same area, 25 percent of the nations population is concentrated. Second, the average size of the farms in the northeastern region is approximately 169 acres, compared to a national average of 417 acres. Third, the value of the farmland in the northeastern states has been increasing faster than that in the nation as a whole, nearly tripling in value between 1967 and 1976. Also, the quality of the land on small farms in this area is often not particularly good. Another factor that has become increasingly inportant in recent years is the skyrocketing cost of transporting food to the large population centers of the Northeast. The latter factor has already and will likely become an increasingly important factor in determining what crops are grown in what regions of the country.

Taking the above factors into account, I feel that vegetables have to be considered as a viable option for making a small farming operation a profitable venture. Vegetables are high value crops that are suited to intensive culture on small parcels of land. The demand for these commodities is high and proximity to large population centers makes it possible to transport and market high quality products with minimum costs. Also, even if the land is marginal in terms of fertility, drainage, etc., most if not all soils can be modified or improved so that one or more species of vegetables can be satisfactorily produced. The current importance of vegetable production on small farms in the Northeastern region has been documented by Kerr (6).

A "small farmer's" decision on how he should use his land depends in large part on whether the intent is to use the income derived from the farm to supplement the family income or whether it is to be the primary or sole source of income. Also important is the availability of labor and its cost. If vegetable production is considered, it must be recognized that it is a labor intensive endeavor.

Our specific goal in the Vegetable Laboratory has been to explore ways to help the small farmer maximize his profit growing vegetables. Although they are not the only factors in determining profitability, keeping the available land productive during as much of the year as possible and increasing yields per acre are major factors. Keeping a parcel of land continuously productive can be accomplished through the use of intercropping and sequential or multiple cropping. This is nothing new, but it has not been practiced as extensively in this country as in other countries such as Japan, China, and Israel. Various indices (crop intensity, multiple cropping, diversity, harvest diversity, simultaneous cropping, cultivated land utilization) have been developed to measure and compare farmland use and production in multiple cropping systems (1, 2, 4, 7, 8, 10, 11).

The right combination of cultural practices and cropping schemes must be determined in order for the farmer to maximize the usage of his land. Cultural practices do have a great influence on the maturity of crops; the insects, diseases and nematodes that attack them, the amount of nutrients and water required to grow them; the quality of the commodities; the carry over of soil nutrients and pesticide residue from one crop to another, and last but not least, the economics of growing crops.

My interest has been to look at cultural practices that lend themselves to intensive production of vegetables on small parcels of land so that I can determine their practicality for this particular area and to assess what problems an intensification of production creates such as alterations in the populations of disease producing organisms, insects, nematodes, weeds; concerns over soil compaction and soil fertility; the buildup of pesticides in the soil, etc.

Specific studies that we have conducted have involved an evaluation of the effects of aluminum mulch on the growth of several crops; a comparison of different types of mulches on muskmelon production; the interactions of various cultural practices and their practicality in combination with various cropping sequences; the effectiveness of degradable plastic mulches, and the feasibility of using polyethylene tunnels to extend the growing season.

In 1977, William Cantelo[2/] and I assessed the effects of aluminum foil mulch on the growth of cabbage, acorn squash and pickling cucumbers and the insects that attack them. This study was a follow-up to earlier work by Smith and Webb (9) who showed that the use of aluminum mulch repelled aphids and subsequently reduced the amount of virus infection in plantings of cucurbit crops.

[2/] Research Entomologist, Vegetable Laboratory, Beltsville Agricultural Research Center.

The use of aluminum mulch resulted in yield increases of 26 percent, 49 percent, and 82 percent for squash, cabbage, and cucumbers respectively. These increases were attributed largely to improved soil moisture retention. Perhaps more interesting than the yield increases was the apparent protection the mulch provided cabbage plants from a high population of cabbage maggot (Hylemya brassicae). Of 144 plants in the foil-mulched and unmulched plots, 1 in the foil plots and 12 in the unmulched plots died during the season with maggots being the principal cause of death. The mean numbers of larvae and pupae per plant in the unmulched plots were 3.94 and 1.00 respectively versus 3.05 and 0.65 in the mulched plots. These differences were not statistically significant, although the foil-mulched plots consistently had approximately 25 percent fewer insects than the unmulched plots. Beyond the number of insects, it was apparent that insect development was slower under the aluminum foil and thus damage was less. This was presumably due to the soil temperatures being lower under the foil than in the unmulched plots.

In a second cabbage planting, plants were examined regularly for eggs and larvae of the imported cabbageworm, Pieris rapae. A total of 180 eggs and 193 larvae were observed on plants in the foil-mulched plots versus 167 and 171 on the unmulched plots. The differences were not statistically significant. It is evident from the data and from observing cabbageworm butterfly movement in the plots that the aluminum had no effect on this insects behavior. The insect populations in the cucumber and squash plantings were too low to obtain meaningful data.

Even though there has been extensive research on the use of synthetic mulches for vegetable production (5), there are continually new products on the market and new ideas for uses of these mulches. In 1978 and 1979, Richard Dudley, Floyd Smith[3] and I studied the effects of four synthetic mulches on muskmelon production (3). The materials used were aluminum foil on paper, embossed aluminum on black polyethylene, black polyethylene, and embossed white polyethylene on black polyethylene. Aphid populations in the plots were monitored throughout the growing seasons and yield records were taken (table 1).

In 1978, aphid flights were fairly uniform and at a very low population level throughout the trapping period. There was no marked population peak of winged aphids such as occurs in some years with the green peach aphid from potatoes, or corn leaf aphid from corn, or pea aphid from alfalfa.

Aphid counts on melon plants growing on all four mulch treatments were lower than from the plants on the unmulched check plot with the aluminum on paper having the lowest count.

In 1979 as in the previous year, all four mulches were highly repellent to flying aphids. Aluminum foil on paper reduced aphid catches 98 percent. The experimental product, embossed white polyethylene on black polyethylene, gave a 97 percent reduction, and the embossed aluminum on polyethylene gave an 84 percent reduction. The black plastic mulch gave a reduction of only 28 percent which was comparable to earlier observations made by Smith[4]. No virus infections were detected in any of the plots in this experiment. Although black plastic was less effective as an aphid repellent and in preventing virus infection, the vine growth and fruit yield of muskmelons grown on black plastic were superior to those grown on aluminum mulch. The largest early and total yields were obtained from the black polyethylene treatment, but the fruit size was smaller than that obtained with other treatments.

In 1979, 1980, and 1981, we conducted a factorial experiment involving two irrigation methods, two organic soil amendments, and two types of mulches to study how the interactions of these treatments affect a spring cauliflower, summer tomato, and fall cauliflower crop sequence. The specific treatments included drip and overhead irrigation; composted sewage sludge and animal manure as soil amendments; and black polyethylene and aluminum foil mulches. Data was taken on disease and insect incidence, earliness, yield and quality of the tomato and cauliflower.

The analysis of the 1981 data has not been completed, but a summarization of the 1979 and 1980 results follows. Because of the amount and distribution of rainfall throughout the growing periods, the irrigation treatments had no effect on the yield or quality of cauliflower produced. The presence of a mulch and the type used had a greater effect on earliness and yield than did the soil amendment.

Aluminum foil resulted in earlier heading of cauliflower, but the heads were of marginal size to be considered marketable (table 2). On the other hand, the use of black plastic resulted in later heading but a significantly greater number of marketable heads with greater average head diameter and weight over the season than the non-mulched or aluminum mulched plots. The smallest heads from both the early and total harvest tended to be from the unmulched plots.

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[3] Research Agricultural Engineer, Agricultural Equipment Laboratory and Research Entomologist and Collaborator, Florist and Nursery Crop Laboratory, Beltsville Agricultural Research Center.

[4] Personal communication from Floyd Smith.

Table 1.--Effects of Four Mulch Treatments on Aphid Populations and Yield of 'Gold Star' Muskmelon

Treatment 1/	1978		1979			
	Total Aphids No.	Reduction %	Total Aphids No.	Reduction %	No. Fruit Per Plant	Ave. Wt. Per Fruit (lbs)
Aluminum on paper	5.5	96.3	2.5	98.1	2.33	4.48
Aluminum on polyethylene	15.5	89.6	20.8	84.3	3.22	4.55
Black polyethylene	54.3	63.9	29.3	77.8	2.82	3.97
White polyethylene on black polyethylene (Polyagro Plastics)	74.8	48.6	--	--	--	--
White polyethylene on black polyethylene (Edison Plastics)	--	--	3.5	97.3	3.26	4.30
Check (unmulched soil)	150.5	--	131.8	--	2.07	4.27

1/ Mention of a trade name or a company does not constitute a guarantee or warranty of the product by the U.S. Department of Agriculture and does not imply its approval to the exclusion of other products that may also be suitable.

Table 2.--Interaction of Soil Amendments and Mulches on Yield of 'Snow Crown' Cauliflower

Treatment (mulch/soil amendment) 1/	1st Harvest		Total - 2 Harvests
	Ave. No. Heads/Plot 2/	Ave. Head Dia. (ins)	Ave. Head Dia. (ins)
alum/none	5.9 a	5.8 c	6.7 bcd
alum/manure	5.5 a	6.7 ab	7.0 bc
alum/sludge	5.5 a	6.4 bc	7.6 ab
none/none	4.4 ab	4.7 d	5.6 d
black/none	3.3 bc	6.0 bc	7.4 bc
none/sludge	3.3 bc	4.2 d	5.5 d
black/manure	2.8 bc	7.5 a	8.9 a
none/manure	2.7 bc	4.9 d	6.2 cd
black/sludge	2.5 c	7.3 a	8.0 ab

1/ Mulches; none=unmulched; alum=aluminum foil; black=black polyethylene

Amendments; manure=360 lbs dry animal manure/plot
sludge=390 lbs dry composted sludge/plot
none=5.4 lbs 5-10-5 fertilizer/plot

2/ Yields followed by the same letter are not significantly different at the 5 percent level.

Even though the application rates were adjusted so that the same amount of nitrogen was provided by each treatment, plots amended with animal manure or composted sewage sludge tended to yield larger heads at both the first harvest and over the season than those where only commercial fertilizer was added. The entire planting was treated with an insecticide at planting so there was no opportunity to observe any effects of aluminum on cabbage maggot.

When tomatoes followed cauliflower in 1979, those plots amended with animal manure or sewage sludge yielded a greater number of marketable fruit than did those where only an equivalent amount of nitrogen fertilizer was added (table 3). However, there was no effect on total fruit yield for both the early and total season harvests.

Black polyethylene and aluminum foil mulch both resulted in reduced total yields for the first harvest, but greater total and marketable yields for the season. An evaluation of the interactions between soil amendments and mulches shows that the greatest early total weights were obtained where no mulch was used regardless of the soil amendment. However, over the season, the four combinations involving the two mulches and two soil amendments resulted in the largest number of total and marketable fruit and were not statistically different.

In 1980, the use of sprinkle or drip irrigation did not result in statistically significant differences in total weight, marketable number or marketable weight of tomatoes at either the first harvest or for the season, but the trend was for greater yields when either irrigation treatment was used. Sprinkle irrigation did result in significantly more fruit rotting, primarily buckeye and rhizoctonia, than the drip or no irrigation treatments for the first harvest, but not for the season.

The use of sewage sludge or only inorganic fertilizer resulted in greater yields than animal manure for the first harvest of the season (table 4). However, for the season, the use of manure resulted in significantly greater number of marketable fruit and a definite trend toward a greater weight of marketable fruit.

Aluminum foil mulch was significantly better than no mulch or black polyethylene for producing early marketable numbers and weight of fruit. On the other hand, black polyethylene was superior over the seasons five harvests. An evaluation of the interactions between treatments clearly showed that the effects of the mulches overshadowed the effects of the other treatments. Black polyethylene in combination with other treatments clearly resulted in greater marketable weights while no mulch in combination with other treatments had the opposite effects.

A serious problem associated with the current use of plastic mulches is the year end disposal of the material. Preliminary studies we conducted with commercially available degradable plastic mulches did not give satisfactory results. Under our conditions we found that these materials either degraded too early to be totally effective or did not degrade quickly enough so that the disposal problem encountered with traditional plastic mulches was still a factor. However, further product development and research on their utilization should make degradable plastic films an important factor for the production of vegetables on small farms in the future.

It has been demonstrated that plastic row covers can be effective in promoting early production of warm season crops (12). Equally important in keeping farmland productive for as many months as possible is to explore ways to produce cool season crops even earlier in the spring than is normally possible and to extend production of these crops later into the fall and winter. During 1980 and 1981, we did this by field planting cabbage, cauliflower, broccoli, brussel sprouts, collards and lettuce in slitted plastic tunnels 4 weeks before they would normally be planted in the spring and by planting the same crop at 2-week intervals beginning in late summer.

Our preliminary results indicate that it is possible to harvest cabbage and broccoli up to 3 weeks earlier in the spring from plastic tunnels than from non-covered rows. Harvesting of late planted crops could be extended well into December and January with the use of slitted plastic tunnels. The primary problem encountered was the buildup of insects in the tunnels.

All of the results discussed above are preliminary and have served to create more questions than we have answers. As further research is conducted on the above mentioned or other cultural practices, it must be kept in mind that this must be coupled with research on the economics of using these practices, marketing of the commodities grown, and more effective transfer of research results to the user. It is perhaps in these latter areas where the greatest opportunity to serve "small farmers" exists.

Table 3.--Interaction of Soil Amendments and Mulches on Yield of Five Plant Plots of 'Pik-Red' Tomatoes, 1979

	1st Harvest		Total - 3 Harvests	
Treatment (mulch/amendment) 1/	Total Wt. (lbs) 2/	Marketable Wt. (lbs)	Total Wt. (lbs)	Marketable Wt. (lbs)
none/manure	3.4 a	1.9 a	26.2 bc	12.8 cd
none/sludge	3.0 ab	1.5 ab	28.2 abc	13.1 cd
none/none	2.5 abc	0.9 b	24.9 c	10.3 d
alum/sludge	2.1 bc	1.9 a	32.0 ab	16.5 abc
alum/manure	2.1 bc	1.6 ab	29.9 abc	17.9 ab
black/manure	2.0 bc	1.5 ab	27.8 bc	16.2 abc
alum/none	2.0 bc	1.1 ab	32.4 ab	13.9 bcd
black/none	1.8 c	1.2 ab	25.5 bc	12.9 cd
black/sludge	1.7 c	1.6 ab	35.0 a	19.1 a

1/ Mulches; none=unmulched; alum=aluminum foil; black=black polyethylene

Amendments; manure=360 lbs dry animal manure/plot
sludge=390 lbs dry composted sludge/plot
none=5.4 lbs 5-10-5 fertilizer/plot

2/ Yields followed by the same letter are not significantly different at the 5 percent level.

Table 4.--Interaction of Soil Amendments and Mulches on Yield of Five Plant Plots of 'Pik-Red' Tomatoes, 1980

	1st Harvest		Total - 5 Harvests	
Treatment (mulch/amendment) 1/	Total Wt. (lbs) 2/	Marketable Wt. (lbs)	Total Wt. (lbs)	Marketable Wt. (lbs)
none/none	2.92 a	.85 a	21.5 d	11.8 c
alum/none	1.81 b	1.0 a	35.1 abc	28.5 ab
black/none	1.77 b	.62 a	39.6 ab	28.4 ab
alum/sludge	1.70 bc	1.0 a	30.2 c	23.4 b
none/sludge	1.60 bc	.19 abc	14.0 d	5.9 c
black/sludge	0.77 cd	.52 abc	42.75 a	36.8 a
none/manure	0.54 d	.04 c	17.1 d	11.4 c
alum/manure	0.44 d	.27 abc	33.0 bc	29.4 ab
black/manure	0.33 d	.12 abc	37.5 abc	31.8 ab

1/ Mulches; none=unmulched; alum=aluminum foil; black=black polyethylene

Amendments equal carry over of 360 lbs dry animal manure, 390 lbs of dry composted sludge, and 5.4 lbs of 5-10-5 fertilizer from 1979 plus 5 lbs of additional 5-10-5 fertilizer broadcast over the entire plot.

2/ Yields followed by the same letter are not significantly different at the 5 percent level.

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COLORADO POTATO BEETLE ON TOMATOES: ECONOMIC DAMAGE THRESHOLDS AND CONTROL WITH *BACILLUS THURINGIENSIS*

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ABSTRACT

In simulated feeding studies, the effects were determined of several population levels of the Colorado potato beetle, *Leptinotarsa decemlineata*, on the production of indeterminate and determinate tomato cultivars. First individual larvae and adult insect were confined in petri dishes with tomato-leaf disks and daily consumption was measured with an area meter. In 45 days, consumption of foliage averaged 145 sq. cm. for females and 115 sq. cm. for males. As larvae, the two sexes consumed similar quantities: 1st instar, 1 sq. cm., 2nd instar, 3 sq. cm., 3rd instar, 11 sq. cm., and 4th instar, 26 sq. cm. From these and other data, a model was developed. Foliage was cut from tomato plants in the field to represent 6 theoretical populations of insects throughout the season, and harvested fruit was weighed. At the indicated ratios for female per plant at the beginning of the season, deficits in yield were as follows, respectively, for determinate and indeterminate cv: 0.0006, 2 and 6%, 0.002, 18 and 1%, 0.006, 25 and 27%, 0.017, 29 and 49%, and 0.05, 47 and 50%. *Bacillus thuringiensis* var. *thuringiensis* (Serotype 1), when applied at dilutions of 10^{-1} to 10^{-5} in laboratory tests to tomato foliage infested with 1st-and 2nd-instar larvae, killed at least 90% before they reached the 3rd instar. The high dosages were necessary to kill the older larvae. Insects died 4 to 8 days after treatment, depending on dosage. Adult beetles were not killed but ceased feeding 4 to 7 days after exposure. Weekly applications at 10^{-3} and 5x10^{-2} of the *B.t.* formulation in the field provided good plant protection and reduced the beetle population by 80 to 88%.

Keywords: Colorado potato beetle, Leptinotarsa decemlineata, Bacillus thuringiensis, damage threshold, tomato.

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Introduction

Tomatoes are one of the main crops grown on small farms in the Northeastern U.S. (4). The insect pest of greatest concern to tomato growers is the Colorado potato beetle (CPB), Leptinotarsa decemlineata (Say). Early research found that the CPB could not complete its development on tomatoes. Evidently the insect had the genetic plasticity that enabled it to expand its host range. This plasticity also enabled it to overcome most of the chemicals that were initially effective in controlling it (3). As a result the number of efficacious chemicals available are few and are becoming fewer as the CPB becomes resistant to them.

This situation encouraged us to seek alternative solutions to the CPB problem. In one approach we determined the effects of several levels of CPB population on tomato yield. Possibly knowledge of those effects might enable growers to reduce pesticide treatments and thus delay the development of insecticide resistance. In a second approach we evaluated a microbial material that controlled the CPB on potatoes (1).

I - ECONOMIC DAMAGE THRESHOLDS

Materials and Methods

In our early studies of the effect of beetles on yield we tried to isolate known numbers of beetles in tomato plots. Corrals 4x2x0.6 m high of 6 mil black plastic sheeting were erected; 16 tomato plants were planted in each and infested with several population levels of adult CPB (fig. 1). The beetles are reluctant flyers and were considered unable to climb the plastic walls and escape. Many, however, soon disappeared. Marked beetles were placed in the corrals and were found in other plots, some as far as 500 m away. Under our conditions beetle movement was evidently much greater than that reported by Logan and Casagrande (6) who maintained various beetle densities in open plots of potatoes. The beetle may be more restless on a less preferred host like tomato. Next we confined the beetles with tomato plants in 2x2x2-m saran screen cages. Population development was often very slow with high mortality--possibly because of high temperatures in the cages.

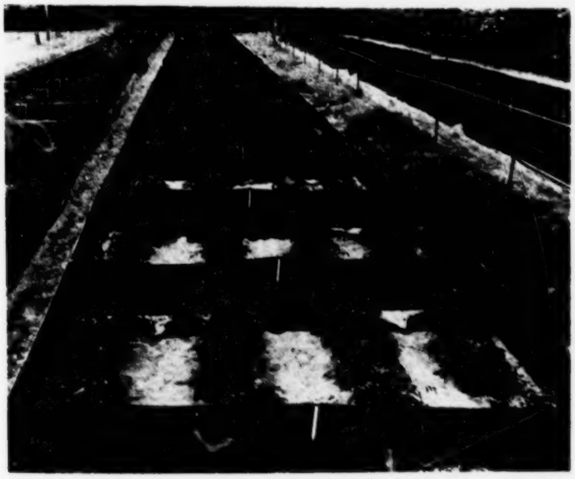

Figure 1. Plastic corrals used in attempt to confine Colorado potato beetle.

Instead of using live insects we decided to simulate beetle feeding by removing known quantities of foliage. We developed a model that described the daily foliage removal of a population over two generations.

First, the amount of foliage consumed by beetles at each stage was determined. We placed 24 male and 22 female newly emerged beetles, each in a separate petri dish with 3.3 sq. cm leaf disks from tomato cv. Manapal. Fresh disks were added daily and the leaf area remaining was measured with an area meter. The beetles were held in a chamber at 24°C with a photoperiod of 18 hours. Foliage consumption by 199 larvae was determined in a like manner. For each insect we recorded the instar daily and the sex at maturity.

On the basis of foliage consumption we developed a model for calculating field damage to a tomato crop over a season. This model assumed that a female laid an egg cluster containing 35 eggs every other day for 14 days, a total of 490 eggs. Survival from egg to 1st and 2nd instar was 0.68, to 3rd and 4th instar 0.57, and to adult 0.39. These estimates were calculated from life tables developed for beetle feeding on potatoes (2). Mortality may be higher on tomatoes. The lengths of stages were: 9 days for the egg; 4 days each for the first 3 instars; 5 days for the 4th; and 8 days for the pupal stage. Adults were assumed to live for 31 days. We recognize the artificiality of the model but believe it approximates the natural situation.

We assumed the first egg cluster was laid May 27. Calculations were made for initial populations of female beetles of 0.05, 0.017, 0.006, 0.002, and 0.0006 per plant. To simulate this damage, we cut disks of 1.9 sq. cm. from the edge of the leaves 3 times a week in the test plots beginning May 23. As the theoretical population increased, the use of disk cutters became too time-consuming and half a leaf at a time was cut with scissors.

Each test plot consisted of 20 tomato plants with four replicates for each of the 5 levels of defoliation plus an undefoliated check. The design was a randomized block. We used two cultivars of tomatoes, Supersonic, an indeterminate variety, and Campbell-28, a determinate variety. Each cv. had a complete set of 24 plots. The ripe fruit were harvested once or twice a week until frost. The fruit were counted and weighed.

Results

Table 1 lists the daily consumption of the adult beetles for the 45 days. Some beetles lived more than 45 days but ate little tomato foliage. One female fed for 136 days before dying and one male for 218 days. Female beetles consumed 26% more foliage than males. Males and females consumed 25% of their total intake by day 4 after emergence and, respectively, 50% by days 14 and 9, and 75% by days 30 and 16. Thus foliage consumption was less age dependent in males than in females. Tamaki and Butt (7) found that for the 10-day period after emergence unsexed beetles ate 6.87 sq. cm. of potato foliage; our beetles ate 6.34 sq. cm. of tomato foliage.

Table 1. Daily tomato foliage consumption (sq. cm.) of adult Colorado potato beetles.

Age (days)	Female Mean	Female Standard Error	Male Mean	Male Standard Error
1	7.69	0.87	8.23	0.57
2	11.80	1.23	8.45	1.11
3	13.97	1.21	8.18	1.22
4	12.01	1.38	5.84	0.86
5	8.10	1.00	3.76	1.05
6	5.56	0.82	3.13	0.76
7	6.13	0.74	3.03	0.46
8	4.03	0.91	3.18	0.92
9	3.67	0.57	2.25	0.66
10	5.72	0.92	2.11	0.52
11	4.37	1.15	4.36	0.89
12	6.35	1.16	2.02	0.68
13	5.86	1.57	1.35	0.69
14	4.90	1.72	2.59	0.45
15	5.07	1.66	3.16	0.80
16	4.69	1.27	2.09	0.64
17	3.00	1.27	1.55	0.95
18	2.73	0.97	1.42	0.03
19	2.07	1.16	2.31	0.87
20	1.81	1.02	2.33	0.12
21	1.49	1.41	1.50	0.14
22	0.85	0.77	1.66	0.21
23	1.85	1.56	1.61	1.17
24	2.32	1.89	1.76	1.47
25	1.47	0.95	0.80	0.53
26	0.96	0.65	1.00	0.40
27	0.61	0.53	2.02	0.73
28	0.57	0.50	2.60	0.70
29	1.60	1.60	1.17	0.12
30	0.59	0.59	1.96	0.01
31	0.45	0.45	2.08	0.05
32	0.54	0.54	1.88	0.15
33	0.54	0.54	2.17	0.14
34	0.54	0.54	1.75	0.27
35	0.19	0.19	2.02	0
36	3.11	1.76	1.89	0.14
37	0.64	0.64	2.00	0.75
38	1.23	0.81	2.26	0.76
39	0.70	0.37	2.24	0.75
40	0.70	0.37	2.90	1.41
41	0.64	0.33	1.71	0.45
42	1.80	1.24	1.22	0.93
43	1.12	0.65	1.22	0.93
44	1.01	0.61	2.13	0.87
45	0.02	0.02	0.03	0.26
Total	145.07		114.92	

For the development of the model the adult daily consumption was considered to be for 1-5 days, 8.80 sq. cm.; 6-10 days, 3.88 sq. cm.; 11-15 days, 4.00 sq. cm; 16-20 days, 2.22 sq. cm.; 21-25 days, 1.53 sq. cm.; and for 26-31 days, 1.31 sq. cm. Figure 2 depicts the calculated consumption of a population originating with one female on May 23.

Foliage consumption by larvae is listed in table 2. Adult female beetles are usually conspicuously larger that adult males, but the amount of foliage eaten differed little between larvae that were to develop into males and females. Consumption by larvae was 49% more than that reported by Tamaki and Butt (7) on potatoes. Because tomatoes are a less preferred host than potatoes, possibly the larvae must consume more tissue to obtain sufficient nutrients to complete development. Latheef and Harcourt (5) made a similar observation. For development of the model, values (sq. cm.) for daily consumption assigned to instars were; 1st, 1; 2nd, 3; 3rd, 11; and 4th, 25. At the highest defoliation level (female/plant) the yield of both determinate and indeterminate tomato cultivars was reduced by nearly 50% (table 3). Analysis of variance showed that the effect of defoliation was similar on fruit weight but not on fruit number from the two cultivars. Yields differed little between the two lower infestation levels and uninfested plants for the indeterminate cultivar. The high variance of the yields from the determinate cultivar prevented clear statistical differences. The difference in weight was significant only between the highest level and control. The data suggest, however, that only the lowest infestation had no appreciable effect on yield. We are continuing this research and will plan to study higher theoretical populations of the Colorado potato beetle.

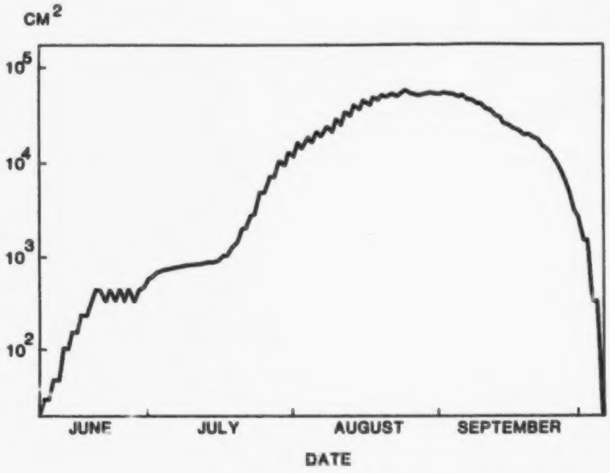

Figure 2. Projected tomato foliage consumption by two generations of the Colorado potato beetle beginning on May 23 with one fertile female beetle.

Table 2. Tomato foliage consumption (sq. cm.) by each instar of the Colorado potato beetle.

Instar	Female		Male	
	Mean	Standard Error	Mean	Standard Error
1	1.11	0.06	1.05	0.08
2	2.74	.37	3.01	0.33
3	11.26	1.01	10.30	1.00
4	25.94	1.71	25.49	1.63
Total	40.96	5.87	39.58	1.23

Table 3. Effect of several defoliation levels (female per plant at beginning of season) on yield per tomato plant.

Female/plant	Determinate cv.1/		Indeterminate cv.1/	
	Weight (kg)	Number	Weight (kg)	Number
0.00	4.37 a	44.08 a	6.98 a	41.18 a
.0006	4.29 a	43.10 ab	6.55 a	39.08 a
.002	3.59 ab	35.98 abc	6.88 a	38.44 a
.006	3.26 ab	31.34 abc	5.13 b	29.58 b
.017	3.10 ab	30.93 bc	3.53 c	19.21 c
.05	2.33 b	24.74 c	3.49 c	17.95 c

1/ Means in a column followed by the same letter are not significantly different according to Duncan's multiple range test, P=0.05.

II CONTROL WITH BACILLUS THURINGIENSIS

Materials and Methods

Laboratory Tests-An experimental preparation of *Bacillus thuringiensis* var. *thuringiensis* (Serotype 1) containing spores, crystals, and B-exotoxin was tested against the CPB in laboratory feeding tests. The *B.t.* preparation (serial dilution of 10^{-1} through 10^{-5}) was sprayed with aerosol containing a chloroflurocarbon on tomato leaves that were about 2.5 cm. long. Leaves were sprayed until dripping, allowed to dry, placed in a vial with a cotton plug and water, and then held with 20 beetle larvae or adults in a clear plastic box at 24°C with a 17 hr. light, 7 hr. dark cycle. Additional treated foliage was supplied when necessary. Controls were sprayed with water. Each test was replicated three times. Mortality was determined daily from day 3 until day 12 after the initial treatment.

Field tests-The same *B.t.* material also was tested in the field. Water dilutions were sprayed on tomato plants weekly, and the degree of protection from CPB was determined. The dilutions were applied with a compressed air sprayer to the leaves until dripping. Controls were sprayed with water.

In the field test, there were 36 plots, with 12 tomato plants each, and four replicates of 3 control (water sprayed) and 6 test plots. Thus, one test plot in each replicate was sprayed with one of the three dilutions ($5x10^{-2}$, 10^{-3}, and 10^{-4}) of the *B.t.* preparation. When plants were about 5 cm high, one adult male and one adult female CPB were placed on each plant.

Results

Laboratory Tests-When 1st-and 2nd-instar CPB larvae were fed tomato foliage sprayed with any dilution between 10^{-1} and 10^{-5} of the *B.t.* preparation at least 90% were killed before the 3rd instar. As the dosage decreased, however, the time necessary for 90% mortality increased from 4 days at 10^{-1} to 8 days at 10^{-4}. In comparison with 1st- and 2nd-instar larvae, 3rd-and 4th-instar larvae were less susceptible: similar concentrations produced less mortality and the time necessary for a given level of mortality increased. At a dilution of 10^{-4}, many insects exposed initially as 4th-instar larvae went through pupation and emerged as adults capable of feeding, maturing, and laying viable eggs, however, a few in the laboratory had anatomical deformities attributed to the teratogenic activity of the *B.t.* At a dilution of 10^{-5}, no 4th-instar mortality was detected. Adult beetles exposed to high concentrations ceased feeding in 4 to 7 days depending on the concentrations. These data are summarized in Table 4 .

Field Tests-Because of apparent impaired killing efficiency, the 10^{-5} dilution was not applied in the field test. Because laboratory tests showed that even high concentrations of the *B.t.* preparations would neither kill adult beetles nor prevent them from laying eggs, the field tests were planned to prevent the larvae from developing past the 2nd instar. The *B.t.* preparation was applied once a week, a procedure that prevented most of the destructive 3rd- and 4th-instar larvae from forming and also prevented the development of adults. (Although

Table 4. Effect of serial dilutions of a preparation of *Bacillus thuringiensis* var. *thuringiensis* (containing 20 x 10 ^{9} spores & crystals/ml) on different stages of the Colorado potato beetle. Laboratory Tests.

	Larval Instar		
Dilution	1st and 2nd % mortality-days until dead	3rd and 4th % mortality-days until dead	Adults % mortality
10^{-1}	100 - 4	100 - 5	0[1]
10^{-2}	100 - 4	50 - 6	0[2]
10^{-3}	87 - 4	90 - 10	0[3]
10^{-4}	90- 8	80 - 8	
10^{-5}	0	0*	

[1] stopped feeding at 4 days
[2] stopped feeding at 6 days
[3] stopped feeding at 7 days
* pupated and emerged

laboratory tests indicated that adults on treated foliage refused to feed after a period of time, no data were gathered to confirm this behavior in the field).

Two weeks after the adults were released into the tomato plots (10 days after 1st spray), both egg masses and adults were counted. Distribution was similar among treatments and controls (Table 5). After two additional weeks of treatment, however, counts of larvae and adults showed significant differences. The two highest concentrations of the *B.t.* preparation had reduced the populations by 80 to 88% as compared with the controls; the lowest concentration (10^{-4}) had not changed the populations significantly. Feeding damage was severe to both the control plants and plants treated with the 10^{-4} dilution, but plants treated with higher concentrations were almost completely protected.

Conclusions

For definitive damage thresholds, additional data are needed. The results of the microbial studies indicate that *B.t.* var. *thuringiensis* is indeed toxic to the CPB. When concentrations of 10^{-3} and 5×10^{-2} were sprayed on tomato foliage, they protected the leaves adequately for one week; when leaves were ingested by 1st- and 2nd-instar larvae they reduced the beetle population by nearly 90%. The material neither kills adult beetles nor prevents the female from laying viable eggs but may stop feeding of adult beetles.

Acknowledgements. This study would not have been possible without the assistance of the following: W. R. Smith and G. B. White, Agricultural Research Technicians; and B. F. Harrison, R. M. Noland, L. Venables and A. M. Wieber, Biological Aides.

Table 5. Effect on Colorado potato beetles on tomato plants of weekly application of spray containing dilutions of a preparation of *Bacillus thuringiensis* var. *thuringiensis* (20×10^9 spores and crystals per ml). Field tests.

Dilution	Average number per plot 10 days after 1st spray egg masses	 10 days after 1st spray adults	 25 days after 1st spray larvae & adults*	% reduction from control
water only	20.7	4.7	68.8 a	--
10^{-4}	21.2	7.5	60.0 a	81.2
10^{-3}	17.5	4.0	12.5 b	81.2
5×10^{-2}	21.4	5.8	8.0 c	88.4

* means with the same letter are not significantly different at the 0.05 level according to Duncan's multiple range test.

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WEED CONTROL PROCEDURES FOR SMALL FARMS

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J. R. Teasdale [2]

ABSTRACT

The unique characteristics of small farms and the associated requirements for weed control are defined. Herbicides which can be applied to minor-use horticultural crops and which are compatible with multiple cropping systems are most useful on small farms. Weed control systems which provide full season weed control are necessary for the small farmer to realize optimum returns. These systems will involve various combinations of herbicides, mechanical cultivation, mulches, crop rotations, and specialized application equipment. These systems must be tailored to meet the specific weed species, crops, and overall objectives of individual small farmers and the specific weed problem and cropping situation. Good communication between researchers, extension specialists, and farmers is essential to facilitate rapid assimilation of new research findings into small farm practices.

Keywords: Horticultural crops, herbicides, small farm, weed control

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INTRODUCTION

Weed control is a fundamental need of all farmers regardless of the size of their farms. Most basic methods of weed control can be used successfully on farms of any size. A radically new approach to the development and application of weed control technology is, therefore, not required for small farms. However, certain unique characteristics of the small farmer require that different weed control strategies be developed. This paper will define some of these characteristics and the research priorities which are needed to develop the appropriate weed control systems for small farms. Specific weed control recommendations or specific research project results are outside the scope of this paper.

Horticultural Crops

Horticultural crop production is the most popular agricultural enterprise of small farmers of the northeastern region. However, fewer herbicides are available for use with the minor-use horticultural crop than with the major field crop. Recent research in conjunction with the IR-4 program has resulted in the registration of a number of herbicides for certain minor-use crops. This will aid the small farmer in obtaining broad spectrum weed control in many horticultural crops. Each herbicide has a weakness for certain tolerant weed species which will become the dominant weed population if the same herbicide is used continuously for a number of years. Therefore, there is a need for new herbicides for each crop in order to provide a range of products which can control the specific weed spectrum that may develop in any specific field.

The development of new herbicides for the minor-use crops which most typically are grown by northeast small farmers should be an important research priority. Such research should include an evaluation of methods for better use of available herbicides as well as evaluation of new chemistry. Most of the available herbicides have not been thoroughly investigated to determine whether or not different application timing or placement can increase selectivity or whether certain crop varieties may be more tolerant than others. Novel methods for using crop protectants such as charcoal or chemical antidotes may also increase selectivity. In these ways, herbicides which are marginally phytotoxic using conventional application techniques might be applied safely to horticultural crops.

Weed Control Systems

The small farmer in the northeast operates on a limited acreage and requires intensive farming practices to optimize production. As a result, the level of weed control needs to be higher on small farms compared to larger farms. The expenditure per acre is greater and often the land value is greater, therefore, the need to produce a greater return per acre is essential. Weeds can interfere with crop production by interfering with harvesting operations and reducing crop quality late in the season as well as reducing yields through direct competition for essential growth factors throughout the season. Therefore, full season weed control is important for the small farmer to realize optimum returns.

Full season weed control is difficult to obtain in horticultural crops. Most fruit crops are perennial and require weed control for the entire growing season. Lack of soil preparation each year creates conditions favorable for the development of perennial weeds which are often more difficult to control than annual weeds. Annual applications of single herbicides are usually unsuccessful because perennial weeds are allowed to become dominant and phytotoxic levels of herbicides can develop. The use of systems involving herbicide combinations, annual rotations, and integration with other methods are needed to solve these weed control problems.

Vegetable crops are generally low growing and/or do not produce a full-leaf canopy. As a result, many are poor competitors with weeds and also require full season weed control for maximum production. Grower experience and research has shown that any single method of weed control performed at planting is insufficient to obtain full season weed control in most vegetables. A herbicide program involving both planting and post-emergence applications is usually necessary for achieving full season weed control. Tractor cultivations and plastic mulches are often included with herbicide programs to improve weed control and provide additional production advantages for some crops. More research is needed to identify which systems of weed control are economical and efficient under different growing conditions.

Multiple Cropping

Most small farmers grow an assortment of fruit and vegetable crops. The resulting cropping systems of small farms are more complex than those on large farms and require more intensive management. As a result, weed control practices are also more complex and require intensive management to be effective. Herbicides must be chosen for their residual phytoxicity, as well as their weed control properties. Many areas in the northeast can support two or three crops per field each season, and herbicides can be used only when they are compatible with succeeding crops in the rotation. Herbicides which can be applied to a wide range of horticultural crops are valuable to the small farmer because they allow more flexibility in arranging crop sequences and simplify the number of herbicides which need to be applied to simultaneously planted crops.

Recent herbicide development has emphasized specialized products for controlling specific problem weeds in agronomic crops. Some of these herbicides will help the small farmer too, even though the small farmer has a greater need for broad spectrum herbicides. Such herbicides ideally should be safe on many horticultural crops and provide control of a complimentary spectrum of weeds to those already controlled by available herbicides.

Weed Control Methods

Weed control by herbicides is the most effective and economical method available. It would be desirable if a herbicide program alone could provide complete weed control. However, in certain cropping situations, limitations on the weed control spectrum and/or selectivity of the available herbicides may require the use of selected non-chemical methods for supplemental weed control. Non-chemical methods alone can rarely provide complete full season weed control without hand labor.

Mechanical cultivation provides only temporary control of escaped weeds; however, no residual control is obtained. It can be a useful tool when integrated with a herbicide program. For example, in some orchard situations, cultivation can be used to remove and/or prevent the establishment of perennial weeds where an adequate herbicide is not available. Some cultivation may also be desirable from a cultural standpoint. This, however, must be integrated with the herbicide program so that the two practices are compatible.

Mulches, such as plastics, straw, and wood chips, can provide good weed control, as well as favorable soil moisture, temperature, and aeration conditions for plant growth. Many horticultural crops respond to mulches with increased yields and earliness which alone can justify their use. Clear plastic mulch requires the use of herbicides or fumigants, whereas, the opaque mulches, such as black plastic, can provide complete weed control within the row. Herbicides are required for control of weeds between plastic strips. The limitations on the use of plastic mulches are their expense and the difficulty of removal.

Most cultural practices for growing crops influence both weed species and weed control and can be manipulated to supplement primary weed control practices. Multiple cropping practices of most small farmers allows truly creative approaches to weed control through crop rotation practices.

Biological weed control has been used successfully for controlling a few specific weed species particularly in range and aquatic situations. It has potential for controlling a specific problem weed in perennial horticultural crops and for reducing the pressure of a specific problem weed from the area surrounding cropping fields. Biological control, however, is not a viable possibility for general weed control in crops. Control is not complete or rapid enough to prevent competition from impeding the development of most crops. Furthermore, biological control is targeted for specific weed species and cannot prevent other weeds from taking its place.

Equipment

The equipment requirements for small farms are varied and can range from the very sophisticated and expensive to the most simple. Conventional sprayers and cultivation equipment are affordable and suitable for most small farm operations. Simple sprayers and cultivators may be the only tools available. In certain cases, with small acreage, hand labor may be the major means of weed control especially if cost-free family labor is available. Equipment designed for hand operation could be very useful to these farmers. Such equipment also could offer the opportunity for more selective placement of herbicides than would be possible with tractor mounted equipment. For example, a self-feeding, hand-held herbicide wiper utilizing a hockey stick which was developed at the Appalachian Fruit Research Station could be used for applying a non-selective herbicide for control of escaped weeds in many horticultural crops.

Much of the specialized equipment needed in horticultural crops must be specially built. Over-the-row spray booms which improve precision and provide uniform coverage can be used to spray both sides of a row crop ranging from vegetables to tree fruits. Shields for lifting and spraying herbicides beneath horticultural crops are very useful tools. Injection equipment for placing a herbicide beneath the soil surface is a tool that allows certain herbicides to be used in a different manner. Equipment that places a protective layer of activated charcoal above a seeded crop is another example of equipment used to improve selectivity. Special additives and spray tips and spray heads that greatly reduce spray drift are used by some small farmers. When controlled release formulations of herbicides are available, the small farmer with the specialty crops will be the first to utilize them. Granular formulations of herbicides greatly increase the selectivity and are a very useful tool to the small farmer.

Recently developed techniques of applying non-selective herbicides to weeds growing taller than the crop, utilizing either a wiper or a recirculating sprayer has limited value in horticultural crops. Even though a wiper can be built by the farmer or purchased at a reasonable price, it should not be considered as a basic part of the weed control program. Severe competition has occurred in many horticultural crops before the necessary height differential has been achieved for wiper applications. This technique is a useful tool for treating troublesome perennial weeds, however, it should not be relied upon to replace conventional practices for annual weed control.

Information Transfer

Small farm operations in the northeast vary tremendously. Growing conditions range from sandy coastal soils to the heavier piedmont soils and from the short growing seasons of New England to the relatively long seasons of Virginia. Farming operations vary from part-time to full-time and from technology intensive to manual labor intensive. Educational background and motivation of the farmer also vary tremendously.

Given such great diversity of farming conditions and philosophies there is obviously no single weed control system which is suitable for all northeast small farmers, but in most cases there does exist a practical solution for specific weed control problems. Most of the tools for obtaining adequate weed control are available--the problem becomes that of transferring this information to the farmer. This involves identifying the weeds present and then tailoring a weed control and crop rotation system which will provide both short-term and long-term weed control.

The burden of information transfer falls on the agricultural extension system and there is a need for this system to reach out to small farmers. A close relationship between research and extension facilitates rapid transfer of new knowledge. This interaction is beneficial to both the researcher and the extension specialist. If small farmer attitudes are resistant to change or nurture excessively rigid farming philosophies, they can only prevent the requisite flow of information and ideas. If extension specialists, researchers, and small farmers actively seek advice and exchange ideas, a major hurdle toward achieving good weed control on small farms will be overcome. Only through a vigorous information exchange system can the results of future research be made available to benefit the small farmer.

PEST RESISTANCE IN HORTICULTURAL CROPS: TOMATO AND APPLE

Jules Janick [1]

ABSTRACT

Genetic resistance is the most attractive method of pest control provided resistant cultivars can compete in the marketplace with standard cultivars. The incorporation of genetic resistance is best attempted for these pests and diseases which limit present production. The objective of incorporating genetic resistance to all present and future pests is obviously unrealistic so incorporation of pest resistance must be considered as but one component of a pest management system.

Keywords: Apple, *Malus domestica*, tomato, *Lycopersicon esculentum*, plant genetics, plant breeding, small farms.

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Success in the production of horticultural crops demands constant and careful attention to the control of a myriad of destructive diseases and pests. There are two approaches to pest control. One approach is directed at the pathogen or pest itself and involves the use of techniques that prevent or restrict invasion of the plant. Such techniques interfere at some point with the successful completion of some stage in the "disease" cycle. This approach includes such practices as legal control (quarantines, inspections of plant materials), cultural control (roguing, surgery, sanitation, rotations, special growing techniques), physical controls (screens, traps, hot water treatments), and chemical control (pesticides, repellents). The other approach is directed toward directing the plant's ability to resist or at least tolerate intrusion of the pathogen or pest through genetic resistance. Genetic resistance varies from complete absence of injury (immunity) through various degrees of partial resistance. Tolerance is a type of resistance in which the plant suffers some injury but is able not only to survive but continues to be reasonably productive. The lack of resistance is referred to as susceptibility.

Various levels of resistance to viruses, bacteria, fungi, nematodes, and insects, as well as rodents and birds exists in agricultural crop plants including fruit and vegetable crops. The nature of plant resistance lies in structural alterations or biochemical effects that either prevent or discourage intrusion and persistence of particular pathogens and pests. Some plants show resistance to a whole group of pathogens or pests; others have only a specific resistance to a particular species, or race. When pathogen and plant exists together in a very close relationship for long periods of time it appears that the plant evolves genetic resistance at the same time the pathogen or pest evolves the genetic ability to violate or overcome this resistance. Thus, the spontaneous origin of new races of pathogens is one of the major problems the plant breeder faces in attempting to incorporate genetic resistance into an improvement program.

The incorporation of genetic resistance would appear to be the ideal solution to control pests. Genetic resistance does not depend on the vigilance of the grower but continues night and day, day after day. Genetic resistance in a stroke eliminates costly pesticides, pesticide application equipment, and residue problems. Once the new cultivar is produced the cost of control is nil. However, it is clear that complete dependence on genetic resistance is wishful thinking. Total reliance on natural resistance is based on the naive assumption that plant biotic environment is static rather than dynamic. The fact is that our crop plants feed not only humans but a host of other organisms. New races of pathogens and pests will continually appear and any shield of resistance will be sequentially challenged by new lances of increased pathogenicity and virulence. Further new pests and diseases will continually appear through introduction, and it is unlikely, even though resistance may be available, that all the resistances can be combined together with acceptable quality and productivity.

Nevertheless, genetic resistance remains the first line of defense upon which growers--large or small--depend. The small grower, more sensitive to short-term disasters, will find it only prudent to rely on genetic resistance whenever possible.

There are various limitations to the use of natural resistance. These include:

1) Unavailability of practical levels of resistance.

2) Resistance available but not incorporated into suitable cultivars.

3) Improbability of obtaining multiple resistance.

4) The development of pathogenic races violating resistance.

5) Difficulties of cultivar shift in perennial species.

6) Problems of combining resistance and other horticultural or agronomic attributes.

It is now clear that in the choice of cultivar, disease resistance must be balanced against performance in the absence of the disease. It is a truism that a disease-resistant cultivar that produces an inferior product will be only valued in time of epidemics. In the absence of the pathogen, resistance will be quickly forgotten and the cultivar will be discarded as a direct consequence of natural selection by growers for high performance.

The use and limitation of disease resistance can best be discussed using two examples - tomato and apple.

Tomato

The tomato, one of the most important vegetable crops, has serious disease and pest problems. Major diseases with sources of resistance are presented in Table 1. The diseases most difficult to control and hence the most critical are two soil-borne diseases: fusarium wilt incited by *Fusarium oxysporum* f. sp. *lycopersici* and verticillium wilt incited by *Verticillium albo-atrum*.

Field immunity to fusarium wilt was discovered in a wild species *Lycopersicon pimpinellifolium* by Bolin and Tucker in 1940. Resistance was conditioned by a single dominant gene (*I*) and rapidly incorporated into adapted genotypes. 'Pan American' was released in 1941 and now practically all new cultivars have incorporated this gene.

Table 1.--Major Tomato Diseases, Pathogens, and Sources of Resistance (2).

Disease	Pathogen	Examples of resistant sources	Gene action
Fusarium wilt	*Fusarium oxysporum* f. sp. *lycopersici* (Sacc.) Snyder & Hansen	Pan American	Dominant
Verticillium wilt	*Verticillium albo-atrum* Reinke & Berth	VR Moscow	Dominant
Bacterial wilt	*Pseudomonas solanacearum* (E.F. Sm.) E.F. Sm.	P.I. 127805A	Recessive or multigenic
Bacterial canker	*Corynebacterium michiganense* (E.F. Sm.) H.L. Jens	Bulgarian 12	Multigenic
Late blight	*Phytophthora infestans* (Mont.) DBy	West Virginia 63	Dominant or multigenic
Early blight	*Alternaria solani* (Ell. & G. Martin) Sor.	68B134 (foliage) Southland (collar rot)	Dominant or partially dominant
Septoria leaf spot	*Septoria lycopersici* Speg.	Targinnie Red	Dominant
Leaf mold	*Cladosporium fulvum* Cke.	Waltham Mold Proof Forcing	Dominant
Gray leaf spot	*Stemphylium solani* Weber	Manalucie	Dominant
Anthracnose	*Colletotrichum phomoides* (Sacc.) Chester	P.I. 272636	Multigenic
Tomato mosaic	Tobacco mosaic virus	Ohio M-R9	Dominant or recessive
Spotted wilt	Spotted wilt virus	Pearl Harbor	Dominant and multigenic
Curly top	Curly top virus	CVF4	Dominant and multigenic
Root knot	*Meloidogyne* spp.	Anahu	Dominant

A new race of *Fusarium* (race 2) was soon found that could attach the (*I*) gene but not until this race became an economic problem in Florida in the mid-1960s was there any serious concern. Fortunately, independent resistance to race 2 was available in several Plant Introduction accessions and soon incorporated into breeding lines. 'Walters' was the first cultivar release to contain resistance to both races of *Fusarium*.

Verticillium wilt was differentiated from fusarium wilt by W. F. Bewley in 1921. Various sources of multigenic resistance were available but real progress awaited the incorporation into breeding lines of a single dominant gene for resistance (*Vr*) originally derived from an accession identified as 'Peru wild'. The first two cultivar possessing verticillium resistance were 'Loran Blood' and 'VR Moscow' released by O. S. Cannon in 1952. At present, fusarium and verticillium resistance are being combined as a standard procedure in most tomato breeding programs. Such cultivars are often identified by the acronym VF.

Considerable progress has been achieved in the development of resistance to other diseases in tomato. Cultivars with resistance to such diseases as nematodes, tobacco mosaic virus, early blight, and bacterial wilt are being released throughout the world but are not generally available in a range of adapted cultivars for specific areas of the United States. Although genetic variability in resistance to various insect pests has been identified there has been no concerted effort to develop insect-resistance in tomato.

The world-wide effort for incorporating genetic disease resistance in tomato has been successful in many areas, as follows:

1) Identification of genetic resistance to most tomato diseases.

2) Determined mode of inheritance for resistance of each disease.

3) Transfer of resistance to breeding lines and a few cultivars.

4) Release of adapted cultivar with combined resistance to verticillium and fusarium (race 1) for the continental U.S.

Although the task is not complete at the present time, small growers in the temperate U.S. do have a wide choice of cultivars with combined fusarium and verticillium resistance, diseases uncontrolled by chemicals. Other pests and diseases must still be controlled by other means. Further progress in breeding should reduce, but probably not eliminate, the dependence on chemical control.

Apple

There are serious problems in incorporating disease resistance into perennial fruit crops, such as apple. As appearance and quality is the most important criteria, the fruit of any disease-resistant cultivar must be fully competitive on the market. However, the present marketing of apples is based on established cultivars which dampens enthusiasm for cultivar change. Further, since apple, as most perennial fruit crops, are long-lived and slow into coming into bearing, growers are reluctant to make rapid changes in cultivars. In order to be useful a new disease-resistant orchard must maintain its resistance for many years but clonally propagated fruit cultivars are especially vulnerable to the occurrence and build up of new races. Most discouraging, the sources of resistance to many diseases are found in wild species with commercially unacceptable fruit, sometimes pea-sized and unpalatable, which demands several generational cycles of crossing and selection (1). Clearly disease-resistant fruit breeding is for those with persistance and not for the faint of heart.

The basic concepts of disease resistant breeding of perennial fruit crops are the same as in annual crops but special features of perennials make disease resistant breeding a formidable endeavor. Breeders of fruit species do face special problems not common in other agricultural crops. These include lengthy juvenile periods and long generation time, large plant size, high heterozygosity, and polyploidy. This is somewhat counter-balanced by vegetative propagation which enables individual genotypes to be perpetuated intact in spite of heterozygosity.

Practically all of the commercial apples are a result of chance selection of desirable seedlings. The major cultivars ('Delicious' and its strains, 'Golden Delicious', 'McIntosh', 'Rome' and 'Jonathan') possess unique combinations of desirable traits selected from literally hundreds of thousands of seedlings. However, each has serious faults which require improvements, among which are disease and pest susceptible. For example, all of the leading apple cultivars are susceptible to apple scab incited by *Venturia inaequalis* (Cke.) Wint. and fireblight incited by *Erwinia* amylovora (Burr.) Winslow et al.; 'McIntosh' is extremely susceptible to scab and 'Jonathan' is extremely susceptible to fireblight.

A further complication is rootstock. Production of apples is based on a multiple component tree--usually a rootstock of one genotype often selected to control tree size, and a scion selected for fruit characters. More complicated possibilities exist; the most complex is a seedling root, a bodystock, a dwarfing interstock, and a scion cultivar but the problems of virus, incompatibility, and expense make such trees of questionable value. Thus, disease-resistant rootstocks and scion cultivars are needed.

In spite of these difficulties, success has been achieved in breeding apples with field immunity to scab. The techniques in the identification, capture, and transmission of the gene that confers resistance, a remarkable story, is the result of a cooperative breeding effort between Purdue University, Rutgers University and the University of Illinois. Individuals who have carried on this program include E. B. Williams, F. H. Emerson, and myself of Purdue University, L. F. Hough and Catherine Bailey (retired) of Rutgers University, D. F. Dayton and J. B. Mowry (retired) of the University of Illinois and the late J. R. Shay of Purdue University and the University of Oregon.

The gene for scab resistance used in this program was first identified by Dr. L. F. Hough from a collection of *Malus* species and hybrids assembled by Professor C. S. Crandall at the University of Illinois in the early 1900s. Apparently the "rediscovery" of Mendel's Law's in the first years of the 20th century prompted Professor Crandall to attempt to relate the inheritance of apple to the fledging science of genetics. Ironically, Dr. Crandall retired in 1927 thinking he had failed to find a single character under single gene control.

In 1942 Dr. L. F. Hough joined the Department of Horticulture at the University of Illinois and "inherited" the breeding material left by Dr. Crandall. As a result of a severe epidemic of apple scab defoliating all susceptible unsprayed apple trees, one progeny showed an almost 1:1 segregation for scab resistance. This progeny was derived from the cross (*Malus floribunda* 821 x Rome Beauty) x (*M. floribunda* 821 x Rome Beauty). Further crosses with two resistant selections from this cross (F_2 26829 and F_2 26830) indicated that resistance was conferred by a single dominant gene subsequently named V_f (*Venturia* resistant from *floribunda*). The 1:1 ratio apparently resulted from the following cross:

$$V_f\ v_f \times v_f\ v_f \rightarrow 1V_f\ v_f : 1v_f\ v_f$$

It was later demonstrated that intercrossing plants heterozygous for resistance would produce the classic ratio of 3 resistant:1 susceptible.

Subsequently studies by J. R. Shay, E. B. Williams, and D. F. Dayton indicated over 20 *Malus* species and hybrids possessed genetic resistance to apple scab (3). Further some of these sources were shown to have definite reaction types e.g. a pit type, a non-pit type, a weakly sporulating type, etc. (3). Eventually through a series of intercrosses (tests of allelism) it was established that many of these sources were due to the same gene. Eventually 6 different genes (defined gene pools) were isolated as follows:

Symbol	Original source
V_f	*M. floribunda*
V_m	*M. micromalus*
V_r	A Russian apple
V_{bj}	*M. baccata jackii*
V_b	Hansen's *baccata* #2
V_a	Antonovka (pit)

However, the development of races of *Venturia* has eliminated some of these genes from the program. Thus, a race has been found (race 5) that can overcome the V_m (micromalus pit type reaction). The V_f gene however, has not been attacked by fungal mutation and is the mainstay of the present program.

The V_f gene had many desirable attributes: 1) it showed no evidence of being violated by fungal races, 2) it was not linked to any undesirable effects, 3) it acted as a true dominant in the diploid, triploid or tetraploid condition, and 4) it was found in 2 selections, F_2 26839 and F_2 26830, that were horticulturally advanced over the original species. (*Malus floribunda* 821 has tiny fruit about 1 cm in diameter.) These two selections formed the basis of the present scab resistant program in apples.

The transfer of the dominant gene for scab resistance was obtained by a series of sexual hybridization of genotypes heterozygous for the V_f gene to adapted, high quality but scab-susceptible genotypes (v_f v_f). In such a cross, half of the progeny contain the dominant V_f gene in the heterozygous condition and can be clearly identified in the seedling stage when innoculated with spores of the cultured organism.

In making crosses, the scab resistant genotype can be either the seed or pollen parent but is usually the pollen parent because the scab resistant selections are usually small trees which will not support a heavy crop. However, abundant pollen from these selections can be easily collected, stored, and shipped. This enabled the actual cross to be made in adapted, frost-free locations over wide areas of North America.

Seed from controlled crosses made each spring have been assembled at Purdue University where they are germinated after stratification and then screened for scab resistance in the greenhouse during the winter in the seedling stage. This phase of the program is under the able direction of Dr. E. B. Williams of the Department of Botany and Plant Pathology. Resistant plants are then moved directly to the field (or nursery). Thus, only scab resistant plants are grown to fruiting in the field at close spacing; selections are then made to provide the best parents for the next generation.

The crossing process must be repeated with the most horticulturally desirable of the scab resistant seedlings. After 3-4 generations this process in essence "captures" the dominant scab resistant gene from *Malus floribunda* 821 and dilutes and eventually replaces all the other genes of *Malus floribunda* with the genes of the high-quality, adapted but scab-susceptible types. These genes are recombined into new combinations to give new types of apple. To avoid inbreeding (backcrossing is equivalent to selfing in bringing about homozygosis) the high quality-susceptible genotypes (equivalent to the recurrent parent in a classical backcross program) and varied each generation.

The program has been very productive. By 1967 five selections with promise were identified as "Cooperative" selections for grower test. At present (1981) 22 such selections have been released and the following named: 'Prima' (Coop 2), 'Priscilla' (Coop 4), 'Sir Prize' (Coop 5), and 'Jonafree' (Coop 22), and 'Redfree' (Coop 13). A selection tested in France was named 'Priam' and a scab-susceptible seedling from this program was named 'Viking' by the Wisconsin Agricultural Experiment Station. Although the program was conceived to increase grower efficiency by reducing fungicidal sprays the impact of the environmental movement and the current energy crisis has greatly increased the relevance of this program.

The success of this modified backcross program was due to a number of factors which should be underscored:

1) A distinct horticultural advantage is immediately conferred to any seedling that possessed the V_f gene.

2) The serendipitous transfer of other desirable genes of *Malus floribunda* such as genes for attractive fruit finish.

3) Unconscious selection for precocity by the continual crossing of selections which fruit in the early years after planting.

4) Selection for earliness and tolerance to other diseases and pests. Disease tolerance is easily recognized because scab resistance makes it possible to grow seedlings without fungicide protection.

Equally important has been the bonus achieved by the coordination of apple breeding that this cooperative program engendered. The program is now formally and informally cooperative between many apple breeding programs throughout the world. In 1963 an informal organization known as the Apple Breeders Cooperative was formed which coordinates research effort among apple breeders with special attention to disease resistance. As a consequence of this effort a number of disease resistant programs have been organized throughout the United States and Canada.

Apple trees with immunity or high levels of disease resistance are of obvious value to the homeowners in assuring them of greater success with less effort. The advantages to the commercial grower include the following:

a) Practically the complete elimination of sprays on young, non-bearing trees. Until trees begin to bear the only spray applications needed would be for the control of mites or scale insects.

b) Reduced cost of spray chemicals resulting from drastic reductions in the number and type of fungicides required. In most instances this would mean no need for fungicides until the late cover sprays when summer diseases may need control measures. However, this assumes that scab-resistant apples be grown in relatively large blocks.

c) Reduced cost of production resulting from savings of labor, gasoline, and equipment maintenance expenses due to the reduced number of sprays required.

d) Increased pack out of saleable fruit resulting from the elimination of fruit losses due to scab infection.

e) Reduced problems with spray residues on the fruit and in the environment, an item of ever increasing importance in grower relations with the consuming public.

It is, of course, obvious to all growers that it is not enough to simply have these new disease resistant apple cultivars and be able to produce good quality fruit at reduced cost of production. The fruit must also be sold through the market channels and eventually to the consumer. This is where the major "road block" presently exists. It is difficult to sell new, unknown cultivars in large quantities to a consuming public that has been heavily preconditioned to purchase 'Delicious', 'Golden Delicious', 'Jonathan', or 'McIntosh'. For any new cultivar to become popular with the consumer and eventually create a market demand it must be either (a) similar to an existing popular cultivar and marketed under that name or (b) possess such outstanding characteristics of tree growth, yield and high fruit quality that it will be widely accepted by both the grower and the consumer. Several of the new apple scab resistant cultivars have potential for local markets. Such cultivars would be especially adapted for homeowners or those small growers who market their fruit to the consumer via roadside markets or "U-pick" marketing procedures. In this instance, disease-resistant apples should prove of highest value to small farms.

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RESEARCHING METHODS FOR IMPLEMENTING IPM ON SMALL FARMS IN THE NORTHEAST

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ABSTRACT

Integrated Pest Management (IPM) is a developing concept in agriculture which seeks to optimize pest control in relation to the total plant production system in light of economic, social, and environmental conditions. While pesticides continue to be one of the primary tools in crop protection, IPM programs seek to develop methods which minimize the need for this type of control. The education and service components of IPM must be carefully designed or they will overlook the needs of the small farmer. The Cornell IPM effort seeks to develop concepts and educational aides which are applicable to the small farm as well as large operations. Most of the IPM projects in New York operate at the farm level where farmer cooperation and informational needs help shape the form of the program. Components of IPM education and delivery developed in the program include pest fact sheets, visual guide charts, crop protection manuals, a computer-based information system, IPM workshops, and training schools. The changing informational needs of small farmers and the new forms of information delivery have created new challenges and opportunities for extension and research through IPM programs.

Keywords: Environmental, extension, Integrated Pest Management (IPM), Northeast, pest control, pesticides, plant protection, small farms.

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The goal of integrated pest management (IPM) is the optimization of pest control in relation to the total plant production system in light of economic, social, and environmental conditions. In this approach, consideration is given to all types of pests which adversely affect plant production. Pilot IPM projects are developed to prevent or mitigate losses caused by pests through the use of biological, cultural, chemical, and other methods of control. Ultimately, IPM programs seek to provide users and advisors with information and training in the principles and application of IPM. Each IPM project examines the pest problems on a farm and the plant protection decisions a farmer is faced with to determine if those decisions can be improved in the light of new information. In many ways, those involved in IPM programs are researching extension methods of educating and assisting farmers so that they will get the most out of their operation with the least amount of chemical-energy inputs.

During the past nine years, Cornell IPM pilot projects in tree fruit, vegetables, and forage crops have addressed the needs of small farmers as well as those of larger operations. Many of the participants in the projects have been small farmers, i.e., they provide most of the labor and management on their farms and are dependent upon their operation for a significant portion of their income. Some of the farms have been small from an acreage and an income point of view. In developing an IPM approach, we have tried to avoid the danger of believing that modern pest control requires sophisticated monitoring or decision-making equipment such as computers. We have also tried to avoid the danger of focusing all of our efforts into developing one form of IPM implementation such as through a consultant selling IPM services to a farmer. Thus, one perspective has been to develop the necessary IPM information and guidelines for a small farmer to use in implementing his own IPM program. A sort of "do-it-yourself" approach where the technology has a low capital-to-labor ratio. In fact, most of the time, the IPM approach emphasizes labor. Another perspective, no less important than the first, has been to develop a system which blends pest, crop, and weather monitoring with other management practices into an IPM service that can be purchased by small farmers. This approach is more comprehensive than the first in that it includes management practices such as record keeping, calibration of spray equipment, consideration of various pesticide application methods, consideration of various pest management strategies, and evaluation of the crop at harvest.

While both of these perspectives are unique in terms of implementation, they seek to answer some very fundamental questions; questions about pests that have been overlooked to a great extent since the advent of synthetic chemical pesticides; questions that were ignored because pesticides were in a sense the miracle drugs for agriculture. Make no mistake, pesticides are still one of the most important tools we have in our war against pests. However, through IPM, they can be used more judiciously than ever before.

One key element of IPM that was missing on most was the lack of someone looking at the crop in a systematic way to observe pest and crop development. Pesticides covered over so many potential errors in controlling pests that farmers stopped looking. What we have had to do in the Cornell program is to emphasize that someone should be in the field or orchard looking to see what is happening. In many respects, the IPM approach involves trading chemical-energy inputs for labor inputs. However, in emphasizing systematic observations all IPM programs take on the challenge of providing comprehensive guidelines for the observer. Once the observer is in place, the questions that arise are: 1) How do I make my observations? 2) Where do I look for a pest? 3) What does it look like or what should it look like when I find it? 4) When is the best time to look? 5) What does it mean when I find it? 6) What can I do about it? 7) What will the long term effects of weather and crop growth have on this pest? There are, obviously, more questions that could be stated here, but those that are listed are the center of our current research efforts in IPM. At present, basic research efforts in IPM include understanding the best way to sample a pest and observe a crop. To make maximum use of the observers time research is attempting to pinpoint the best time and place to look for pests. For example, studies are underway in several crops to understand the relationships of crop growth, pest biology, and weather. This is leading to methods of alerting agents and farmers to the best time to look for a given pest. Research is also being conducted to relate the levels of pests observed to the need for action. In addition, basic research is being conducted on control methods that offer an alternative to chemical pesticides. In a nutshell, basic research is addressing sampling methods, the long term effects of weather on crop and pest biology, and the use of biological control agents such as beneficial insects. It is also examining the use of pest resistant varieties, the use of reduced rates of pesticides, and the use of cultural methods as a form of pest control.

To appreciate how all this basic research is moving down to the small farmer, we really must examine the ways in which we are researching implementation methods. To do this, we should keep in mind that implementation does not only take place at the farm level, but must also take place in the extension structure. While extension agents should continue to deliver timely information to farmers across the radio and through newsletters, they must have more timely and interpretable information available to them. For example, most of our experience with an excellent extension agent staff in New York indicates that agents have been handicapped to a great extent by not knowing when and where to look for pest problems or, in fact, how to look for them except in an after-the-fact mode. Consequently, much of their information to growers is of a preventative nature, i.e., "Now is the time when this pest usually occurs", or "I've seen this pest causing some problems so you had better apply your control measures". Because of the lack of information to the questions outlined earlier, many extension agents have been forced into a "spray" or "control" mode. It is only recently, as research begins to answer some of the questions outlined above, that agents are changing their approach and encouraging growers to make frequent observations on their crops and relate what they see to other factors.

One more point that must be made here is that all of the finest research in the world will not lead to a great deal of progress at the farm level unless there is some type of return from the farm, back to research. Our studies in New York show that researchers are often handicapped in making advances because of a lack of feedback on their current strategies. Thus, some of the challenge faced in implementing an IPM system in New York revolves around creating the methods and means of returning the results of implementation back to research. For example, a crop protection scientist may develop a new control strategy for a pest which, although logical to him, is in conflict with strategies for a pest of a different kind, or is in conflict with a grower's economic ability to implement the strategy. Through the IPM effort, these problems can be quickly pointed out to research for strategy modification or for incorporation into future research priorities.

The best way to understand the results of the New York IPM effort and how it pertains to small farms is to review some examples. Pilot projects are created at the farm level to explore and develop the various components of IPM. Scouting services are often provided as part of the project because of the need to develop a demonstration project which satisfies rigid operational requirements. The early years of a project demonstrate the possibilities of IPM to those in research and extension as much as to the farmer. Furthermore, the IPM projects document the complexities a farmer faces in assimilating new technologies and in changing attitudes about pest control. After a period of several years, the pilot projects reach a point where an IPM approach is available, and farmers can be instructed in the methods of carrying out their own program or can be directed to an IPM service organization.

Among the implementation aspects that are researched are methods of obtaining the greatest amount of pest and crop information through the least amount of time spent in the field. Most of the current results of these studies have been realized through farmer cooperation. For example, farmers have allowed project personnel to conduct commercial scale studies of the levels or numbers of pests which cause economic damage. Similar studies have explored the use of biological control agents such as ladybird beetles and predatory mites in commercial settings. The unique aspect of this type of research is that all of these studies are influenced and shaped by the day-to-day operation of the farm. This approach is presently being referred to as the farming systems approach where the primary aim is to increase the overall productivity of the farming system. One pilot project in New York which did not start with scouts was conducted with alfalfa growers. Through extension agents and printed materials, growers were instructed in pest sampling and identification. Each week during May and June, participating growers received a post card from their extension agent alerting them to alfalfa weevil development. When the weevil was in its most damaging stage, farmers knew it was time to sample their fields for this pest. Sampling involved walking a 100' circle in the alfalfa field and shaking 30 alfalfa plants over a 2 gallon pail. The larval count and the height of the alfalfa plant were then marked on a chart. With a little help from the chart, the farmers decided to harvest, spray, or do nothing to the crop for the weevil. This is the fastest and easiest IPM decision-making method developed in the Cornell program.

Unfortunately, farmers can't see every pest problem in time to react to it or before it causes economic damage. Some pests, especially plant diseases, appear quickly and usually at or near damaging levels. Most farmers have traditionally found that the best remedy for diseases was a preventive control measure. However, scientists have found that the conditions for several plant diseases can be effectively monitored and even predicted through careful analysis of weather conditions. For example, potato late blight infections can be forecast by monitoring certain weather conditions. Data from a hygrothermograph can be worked into simple mathematical formulas which forecast either the need for control or the suggestion to take no action. Similarly, conditions for apple scab infections can also be tracked with weather equipment, and control measures timed more accurately. Thus, it is now possible to react to some pest problems when conditions are favorable, as opposed to applying control measures in anticipation of conditions which may, in fact, never materialize. In these two examples, a pesticide is still the best means of control, but improved timing usually means less pesticide in the environment.

In one of the New York vegetable projects, decisions for control of a plant disease are based upon weather observations coupled with observations on soil moisture and crop growth. Each of these factors is recorded on a chart which assists the farmer in decision-making. Other elements in the vegetable projects include the use of sequential sampling procedures which allow an observer to make a decision about pest densities without sampling large portions of a field. The projects also introduced pesticide rating charts to assist a farmer in choosing the proper chemical for the pest problems at hand. Scouting reports on the levels of pests each week provide data which can be used to rate the performance of pesticides under commercial conditions. This, in turn, has led to pesticide rating charts for most pest situations. Still other aspects of the vegetable projects include the use of pheromone, blacklight, and sticky traps to monitor insect activity. This activity is recorded on visual pest progression charts which provide a farmer with information on pest levels. The projects also provide information on the proper timing of cultural methods such as cultivating which help keep insect and weed pests in check.

Developments in the tree fruit project include an entire system of tools and techniques which a farmer can follow to implement IPM. The underlying principle for making this system work is based upon a sound understanding of a farmer and his operation. Once the fruit IPM system was in place, several results were realized. The most significant being that fruit quality and quantity remained the same over a six year period while the farmer realized economic gains through reduced pesticide-energy inputs, and at the same time, reduced the level of pesticides being introduced into the environment. In developing IPM principles and practices for tree fruit, we have found that even the small farmer would rather hire-in the IPM service rather than try to take time to do it himself. One reason for this is that small farmers like receiving the individual attention that an IPM service provides. Since some small farmers are part-time farmers, they often cannot be in the orchard or field at the right time. It was also observed that small farmers were looking for the perspective of an IPM advisor who visits many farms and sees the intensity of various pest populations on these farms.

Implementation of IPM is in constant evolution. Some of our current efforts revolve around assisting farmers in the organization of an IPM scouting service. For example, in fruit, the IPM program has helped growers organize a cooperative for pest management services. This cooperative will hire a farm advisor to call on each member for IPM services. Many of the members are small farmers who plan to purchase supplies and share other services through this cooperative.

All of the IPM projects have been supported through several common thrusts. To help address questions of pest identification, the IPM effort in New York has developed single page fact sheets for many of the common insect, weed, and disease pests found on various crops. These fact sheets provide colored pictures of each stage of the pest along with pictures of damage caused by the pest. In addition, the sheets contain a brief description of the biology of the pest, when to look for it, where to look for it, and the actual size of it when it is found. Most IPM projects are beginning to furnish farmers with tables indicating the numbers of pests needed to cause economic damage. Comprehensive IPM manuals have been developed which cover all of the crop protection aspects from sampling and scouting guidelines to the use of biological and chemical control tactics. The IPM program also conducts in-depth workshops and on-farm demonstrations of methods and techniques. In many ways, this may appear to be retracing the steps of the "old" extension agent who attempted to place the latest technology on the farm. Nonetheless, it appears that a return to some of the traditional extension practices must be made to capture the essential ingredients and valuable technologies that were discarded with the advent of synthetic pesticides.

Finally, it would be worthwhile to spend a few moments looking at one other aspect of IPM. If crop protection is going to move into an IPM mode, there must be a dynamic assembly of information and a rapid transferral to user groups. Some of this will be done at the farm level as already discussed. However, some of it will come about through the use of one of the newer tools in agriculture, namely, the computer. Large and small computers will be used to analyze and interpret information and deliver it quickly to the decision point. In New York, we are presently using computers to assist our extension agents in focusing many facts on the decision points of crop protection.

Through our computer-based information system called SCAMP, we are assembling reports from observers in the field, weather data, news items from research, pesticide registration information, pest management strategies, forecasts of pest, crop, and weather developments, and several other factors. This information is available to extension agents at computer terminals in their offices for use in radio shows, recorded telephone messages, and newsletters. Although we presently allow farmers and agribusiness personnel to use SCAMP, we have not geared our system to deliver directly to them. What form this type of technology will be in, if and when it reaches the small farm, is for others to decide. Small farmers may find home computers to be as handy as a tractor in tending the needs of the farm. However, we do believe that a small farmer, using new and developing IPM technologies from extension, will not be forced to rely on expensive equipment or sophisticated forms of information. If anything, a small farmer will have to be a keen observer and a good record keeper. All it may take to make better crop protection decisions in the long run may be a simple set of observations on crops, pests, and weather, coupled with a few interpretive charts.

In summary, the IPM implementation efforts in New York have attempted to assemble the tools and techniques needed to conduct IPM on small farms. The Cornell program has not centered merely on the farmer, but has tried to improve the structures from which the farmer obtains information, and to improve the information itself.

HERBS AS A SMALL FARM ENTERPRISE AND THE VALUE OF AROMATIC PLANTS AS ECONOMIC INTERCROPS

James A. Duke[1]

ABSTRACT

With smaller markets than conventional crops, herbs are a natural candidate for small farmers to consider. Ranging from tropical Hawaii to arctic Alaska, America can grow any herb or spice, now grown elsewhere. Hundreds of herbal products are imported into the United States. Assuming that, in more cases than not, intercropping yields more total biomass, crop, and money than monocropping, the monetary value of herbs is indicated. Many aromatic herbs contain compounds said to alleviate disease, insect and/or weed problems. More than fifty such herbs are specifically mentioned.

Keywords: Essential oils, Fungi, Herbs, Insects, Intercropping, Nematodes, Nitrogen, Small Farm, Spice, and Weeds.

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INTRODUCTION

There are many definitions of herb 1) a non-woody plant, 2) a culinary or medicinal plant or 3) any useful plant. But all plants are useful in one way or another. To me, an herb is a nonconventional crop, not primarily a fiber, food, or fodder, with an odd use, as culinary, dye, medicinal, etc. There are unusual herbal uses of conventional crops, e.g. the use of corn silks as a diuretic. Not all herbs are aromatic, but many are. They are often used as intercrops by small farmers and hobbyist alike. For example, many Europeans still intercrop basil and tomatoes, believing that they make good companions in the field as well as in the pot. There are also many systems of intercropping, one plant alternating with another in the row, or with rows or tiers of rows alternating with rows or tiers of rows, or with rings of so-called repellant species surrounding less repellant species. In one poppy field in Laos, I found a hodgepodge of more than 25 economic plants all intercropped (6). Marihuana encircled a Meo poppy field, reflecting local belief that the plants repelled insects and/or grazing ruminants. Aromatic intercrops may increase the yields of the small farmer, while decreasing the costs. Often herbs are higher priced items than conventional crops, yielding less biomass but more money.

HERBS AND THE SMALL FARMER

Recently (July 13, 1981), the Chemical Marketing Reporter ran an informative article entitled HERB AND SPICE GROWERS IN US FACE PRESSURES GENERATED BY LAND BOOM. According to the article, the US Herb Market relies on domestic production for about 35% of its needs. Three growers produce nearly all the dried herbs from California, which reported more than 1,000,000 pounds dried herb produced in 1978. Among others, they produce basil, chervil, coriander, dill, marjoram, oregano, parsley, rosemary, sage, savory, tarragon, and thyme, all of which I have grown satisfactorily on my small farm in Howard County, Maryland. Nearly all are aromatic intercrops, ideally suited for the small farmer. Prices in 1979 were ca $1000/ton for basil, ca $400/ton for coriander, $700/ton for dillseed, $1000/ton for marjoram, $2000/ton for oregano, $1000/ton for parsley, $700/ton for rosemary, $2500/ton for sage, $2000/ton for savory, $5000/ton for tarragon, and $1500/ton for thyme (10). All can be grown by the small farmer in Maryland or California or for that matter in every state of the Union during summer. Just last month I harvested many of these and several others, grown between grapes and blueberries, as well as between row crops. In the Chemical Marketing Reporter prices for hundreds of herbal or natural products imported into the United States are quoted. In many cases the source, poundage, and consignee are indicated.

VALUE OF AROMATIC INTERCROPS

It is often surprising to the uninitiated to realize the value of such obscure economic plants as spices and essential oil plants. In 1979, the United States exported nearly 10,000 MT of essential oils with a value of $85 million, up from 1978 exports of closer to 8000 MT valued at $80,000,000 (9). Conversely the US imported about 9000 MT worth more than $100 million in 1979, compared with closer to 7000 MT worth slightly less than $100 million in 1978. US 1979 imports are shown on Table 1.

US imports of specified condiments, seasonings and flavoring materials (see Table 2) in 1979 were nearly 150,000 MT worth $200 million, only slightly lower than the record 1978 level. US exports in 1979 fell to 10,719 MT worth about $20 million compared with 1978 shipments of 11,357 MT worth $20.3 million (10).

All told these species average little more than a dollar per kilo. US yields average out, at least among the leading California dealers, close to a ton per hectare.

Just before Time Inc. closed it, the Washington Star issued its 81 Cookbook Part 2 (July 26, 1981) consisting of winning recipes from the readers of the Washington Star. Among the first 100, almost all contained one or more herbal condiments or spices, over and above salt and pepper (black pepper in general considered a spice not an herb). More than 40 different herbs and botanical condiments were cited in the first hundred recipes, and several had five or more herbs in a single recipe. On the other hand curry and fivespice represent combinations of several herbal products.

Allspice occured in only one recipe of the first hundred, (meatpie); basil in 5 (artichoke, chicken, spaghetti, veal, zuccini); bay in 4 (bean, lamb, shrimp, zuccini); capers in 2 (artichoke, crab); caraway in 2 (liptauer, vegetable dish); cayenne in 4 (mushroom, cheeseball, gumbo, salmon); celery in more than 10 (beef, chicken, crab, gumbo, lamb, meatball, sausage, shrimp, zuccini); celery salt in 2 (celery, crab); chives in 4 (giblets, lobster, shrimp, vegetable), cinnamon in 4 (chicken, cranberry, hamburger, veal); cloves in 3 (chicken, cranberry, ham); cumin in 2 (chicken, tofu); curry in 3 (crab, curry, spinach), fennel in 1 (veal); file in 3 (gumbo, rice); fivespice in 1 (chicken), garlic in >35 (artichoke, bean, chicken, crab, fish, guacamole, gumbo, ham, lamb, liver, meatballs, mushrooms, pate, porkchop, seafood, seafood creole, shrimp, steak, tahini, vegetable veal, vegetarian lasagna, and zuccini); ginger in 4 (chicken, porkchop), hickory chips in 1 (porkchops); horseradish in 4 (chicken, salmon, shrimp); juniper berries in 1 (porkchop); marjoram in 2 (liver, porkchop); mint in 1 (hamburger); mustard in >10 (chicken, crab, ham, hamloaf, liptauer, liver, omelet, porkchop, quiche, shrimp, sloppyjoe); nutmeg in 3 (giblets, lamb, veal); onion in >35 (artichoke, bean, beefpie, beefroast, brisket, cabbage, caviar, celery, cheese, cheeseball, chicken, chile, crab, curry, eggplant, guacamole, gumbo, hamburger, lamb, liptauer, liver, meatball, meatpie, mushroom, omelet, port, porkchop, salmon, sausage, seafood, shrimp, sloppyjoe, spinach, stew, tofu, veal, vegetable, vegetarian dishes, and zuccini); oregano in 8 (artichoke, chicken, eggplant, scallop, vegetarian lasagna, zuccini); paprika in >10 (bean, celery, chicken, liptauer, omelet, pork, seafood, shrimp, spare-

Table 1. US Essential Oil Imports (1979)[1]

Common Name	Scientific Name	Import (Kilograms)	Total Value ($)	Value per Kilogram ($)
bitter almond oil	Prunus dulcis (Mill.) D.A. Webb	54,133	187,000	3.59
anise oil	Pimpinella anisum L.	34,049	543,800	15.97
bergamot oil	Citrus sp.	29,424	1,558,800	52.98
oil of camphor	Cinnamomum camphora (L.) J.S. Presl	37,692	91,600	2.43
oil of caraway	Carum carvi L.	10,349	327,800	31.68
oil of cassia	Cinnamomum aromaticum Nees	68,397	3,907,500	57.13
oil of cedar leaf	Juniperus spp.	7,724	276,000	35.73
oil of cedarwood	Juniperus spp.	47,180	93,900	1.99
oil of cinnamon	Cinnamomum verum J.S. Presl	26,474	165,400	6.25
oil of citronella	Cymbopogon nardus (L.) Rendle	645,642	3,474,200	5.38
oil of citrus	Citrus spp.	22,079	765,500	34.67
oil of clove	Syzygium aromaticum (L.) Merr. Perry	781,761	4,300,600	5.50
oil of cornmint	Mentha arvensis L.	208,349	1,792,700	8.60
oil of eucalyptus	Eucalyptus spp.	277,456	916,100	3.30
oil of geranium	Pelargonium spp.	62,570	3,869,200	61.84
oil of grapefruit	Citrus paradisi Macfad.	27,387	58,500	2.14
oil of lavender	Lavandula spp.	140,125	3,325,500	23.73
oil of lemon	Citrus limon (L.) Burm. f.	673,264	10,755,600	15.98
oil of lemongrass	Cymbopogon spp.	179,698	1,214,400	6.76
oil of lignaloe or bois de rose	Ocotea sp?	83,985	921,000	10.97
oil of lime	Citrus aurantiifolia (Christm.) Swingle	813,836	20,966,000	25.76
oil of neroli or orange flower	Citrus aurantium L.	162	159,500	984.62
oil of nutmeg	Myristica fragrans Houtt.	151,591	2,740,400	18.08
oil of onion and garlic	Allium cepa L. and Allium sativum L.	4,213	594,900	14.12
oil of orange	Citrus sp.	2,755,290	2,229,000	0.81
oil of origanum	Origanum sp.	6,385	198,600	31.10
oil of orris	Iris x germanica L.	351	351,800	1,002.16
oil of palmarosa	Cymbopogon martinii (Roxb.) W. Wats.	12,758	298,500	23.39
oil of patchouli	Pogostemon cablim (Blanco) Benth.	237,949	5,857,000	24.61
oil of peppermint	Mentha x piperita L.	3,418	99,800	29.20
oil of petitgrain	Citrus sp.	159,145	1,834,600	11.53
oil of pine	Pinus sp.	1,992	29,200	14.64
oil of pineneedle	Pinus sp.	12,986	207,600	15.98
oil of attar of rose	Rosa sp.	981	1,857,800	1,893.74
oil of rosemary	Rosmarinus officinalis L.	60,359	742,000	12.29
oil of sandalwood	Santalum album L.	32,716	3,169,700	96.89
oil of sassafras	Sassafras albidum (Nutt.) Nees	283,642	948,400	3.34
oil of spearmint	Mentha spicata L.	1,885	28,100	14.92
oil of thyme	Thymus vulgaris L.	8,589	241,300	28.09
oil of vetiver	Vetiveria zizanioides (L.) Nash ex Small	78,744	4,439,700	56.38
oil of ylang ylang	Cananga odorata (Lam.) Hook.fil. & Thoms.	50,410	2,358,400	46.78
other essential oils		936,210	18,406,100	19.66

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[1] Based on Reference (9).

Table 2. US Condiment Imports (1979)[1]

Common Name	Scientific Name	Import (Kilograms)	Total Value ($)	Value per Kilogram ($)
allspice	Pimenta dioica (L.) Merr.	487,300	817,000	1.67
anise	Pimpinella anisum L.	492,200	803,900	1.63
basil	Ocimum basilicum L.	484,500	473,400	0.97
capers	Capparis spinosa L.	657,500	2,606,700	3.96
capsicum	Capsicum spp.	5,190,300	6,273,400	1.20
caraway seed	Carum carvi L.	3,586,000	5,224,700	1.45
cardamom seed	Elettaria cardamomum (L.) Maton	90,600	922,400	10.18
cassia	Cinnamomum aromaticum Nees	9,079,800	6,706,000	0.73
celery seed	Apium graveolens L.	2,149,500	1,577,300	0.73
cinnamon	Cinnamomum verum J.S. Presl	472,300	867,700	1.83
cloves	Syzygium aromaticum (L.) Merr. & Perry	1,321,000	9,091,700	6.88
coriander	Coriandrum sativum L.	3,300,700	1.273,200	0.38
cumin seed	Cuminum cyminum L.	5,802,900	10,626,200	1.83
curry		161,800	455,800	2.81
dill seed	Anethum graveolens L.	556,500	368,800	0.66
fennel seed	Foeniculum vulgare Mill.	1,157,800	933,500	0.80
dehydrated garlic	Allium sativum L.	196,200	362,000	1.84
ginger	Zingiber officinale Roscoe	263,300	459,000	1.74
leaves of laurel	Laurus nobilis L.	371,500	574,900	1.54
mace	Myristica fragrans Houtt.	250,300	523,100	2.08
marjoram	Origanum majorana L.	322,700	317.700	0.98
mint leaf	Mentha spicata L.	250,100	626,000	2.50
mustard seed	Brassica spp.	28,676,100	10,727,400	0.37
nutmeg	Myristica fragrans Houtt.	2,406,200	4,697,800	1.95
dehydrated onions	Allium cepa L.	25,100	40,300	1.60
origanum leaves	Origanum spp.	2,693,900	5,123,700	1.90
paprika	Capsicum sp.	5,567,700	8,325,300	1.49
parsley	Petroselinum crispum (Mill.) Nym. ex A.W. Hill	147,300	244,600	1.66
pepper (black)	Piper nigrum L.	24,482,400	42,546,500	1.73
pepper(white)	Piper nigrum L.	2,755,600	6,828,900	2.47
poppyseed	Papaver somniferum L.	2,364,400	1,442,700	0.61
rosemary	Rosmarinus officinalis L.	245,600	157,500	0.64
sage	Salvia officinalis L.	1,471,000	3,688,800	2.50
savory	Satureja spp.	134,000	258,200	1.92
sesame seed	Sesamum indicum L.	32,099,300	31,648,000	0.98
tarragon	Artemisia dracunculus L.	40,600	215,900	5.31
thyme	Thymus vulgaris L.	815,200	1,358,600	1.66
turmeric	Curcuma domestica Val.	1,539,800	1,684,300	1.09
vanilla beans	Vanilla planifolia Andr.	496,700	18,291,000	36.82
mixed spices		975,000	1,427,400	1.46

[1] Based on Reference (10).

rib); parsley in 25 (artichoke, bean, beefpic, chicken, cornish hen, crab, curry, fish, gumbo, liver, lobster, meatball, mushroom, lamb, pork, porkchop, salmon, scallop, shrimp, spaghetti, vegetarian lasagna, zuccini); pepper (green) in 7 (cheeseball, crab, gumbo, omelet, seafood creole, shrimp, veal); pepper (chili, hot, or jalapeno); in 10 (artichoke, brisket, chicken, liver, shrimp, sparerib, tofu, vegetable); pepper (red) in 3 (gumbo, liver, shrimp), pimiento in 2 (artichoke, cheeseball); rosemary in 3 (lamb, scallops, seafood creole); sage in 1 (porkchop); scallions in 5 (artichoke, mushroom, quiche, seafood, spaghetti); sesame in 1 (chicken); shallot in 1 (mushroom); tabasco in 10 (artichoke, brisket, cheese, chicken, crab, guacamole, gumbo, ham, pate, shrimp, zuccini); tarragon in 4 (chicken, shrimp, vegetable dip); and thyme in 9 (artichoke, crab, gumbo, liver, pate, porkchop, scallop, vegetarian lasagna, zuccini). With an herb in the majority of recipes, the value of herbs to American consumers and small farmers is indicated.

VALUE OF INTERCROPPING

In most cases I have reviewed, the additive values and/or biomass of intercrops have equalled or exceeded the value of either of the intercrops grown as a monocrop. Since different species "mine" the soil differently, display their leaves differently, and utilize the spectrum of soil, fertilizer, space, air, sunlight, and rain differently, two species will obtain more of one or more of these inputs, natural or artificial, than one of the species might from the same area. On small farms overseas, a hidden value of intercropping is the "insurance" value. When one or the other monocrops might fail, the intercrop might survive, enabling the farmer to harvest his "insurance" crop. Ryan et al (21) showed that during wet years a 33% cover of intercropped clover increased cabbage yields by 57%, but decreased yields during dry years.

A companion planting is a special type of intercropping where the planting of one species is supposed to exert some biological control over the other species (11, 19). Having read that walnut (Juglans nigra L.) "droppings" effectively eliminate several species of weeds, I have intentionally planted walnut-tolerant ginseng in the shade of the walnut. Hopefully I won't need to utilize the chemical energy tied up in herbicides to control the weeds in my ginseng patch, although cleavers (Galium spp.), honeysuckle (Lonicera japonica Thunb.), lopseed (Phryma leptostachya L.), and tearthumb (Polygonum spp.) appear to tolerate the walnut. Having read recently (12) that thyme (Thymus vulgaris L.) and onion (Allium cepa L.) deter oviposition by cabbage butterflies, I have used them as companion plants for my cabbage, broccoli, and brussel sprouts (Brassica spp.). In the 1978 Yearbook of Agriculture I noted (7) that many mint species may contain repellants or insecticides like camphor, carvacrol, citral, citronellal, eugenol, furfural, linalool, menthol, and thymol, and fungicides such as furfural, menthol, salicylic acid, and thymol. Perhaps this companion planting will spare me the chemical energy tied up in insecticides and fungicides. Having also recently read (14) that marigolds (Tagetes) cut back on nematodes in okra, Abelmoschus esculentus (L.) Moench., I suggest that marigolds might cut back on the requirements for the chemical energy tied up in nematicides. Having read that dill, Anethum graveolens L., will decrease the incidence of certain grape, Vitis spp., diseases, I planted dill as a vineyard companion crop, hoping to spare some of the chemical energy tied up in fungicide. Of course I am utilizing some of my personal energies in substituting for the pesticide's energy via companion planting. And it may not work. Obese Americans should cease to lament the expenditures of their personal energies, and start to lament the expenditures of our unrenewable energy resources.

Several years ago I purchased the so-called "mole-plant", Euphorbia lathyris L., to discourage moles and other subterranean rodents in my garden. Like castor bean, Ricinus communis L., the "mole-plant" is poisonous, and widely believed to discourage rodents. Some of my plants survived the hard winter of '76-77 and are coming back well in my warm-temperate humid Howard County climate. Imagine my surprise to read in so distinguished a journal as Science that Nobel-laureate Melvin Calvin is calling this the "petroleum plant." Dr. Calvin suggests that the milk from this spurge can be converted to petroleum at the rate of 40 barrels per acre per year. At this rate, he says, an area the size of Arizona planted to "petroleum plant" could meet our current gasoline requirements. I hope Dr. Calvin is right but I fear he is wrong. I suspect that he could obtain more ethanol from the residues than he obtains petroleum, and that an ethanol-gasoline mix might be less polluting than gasoline alone as a fuel.

Perhaps the "petroleum plant", alias "mole plant", might make a good intercrop for jojoba, Simmondsia chinensis (Link) Schneid., another plant found in Arizona. Fruits of jojoba contain a compound very similar to spermwhale oil. Rodents often carry off the fruits when they fall to the ground. Perhaps the "mole plant" as a companion might repel the rodents from the jojoba orchard. It would be interesting to try triple-crop intercropping stratagems with three desert plants that may be very significant energetically. Our tires could be made from guayule, Parthenium argentatum A. Gray, another desert shrub, which could be tried as an intercrop with the jojoba and "petroleum plant." Even if Dr. Calvin is overoptimistic, it is conforting to know that we can raise renewable raw resources for gas, rubber, and spermwhale oil on our American desert.

Many aromatic volatiles, common in many popular "herbs", unquestionably do have effects, greater or lesser, on many of our pathogens, insects, nematodes, and weeds. Such an approach would appeal to many gardeners and small farmers in the United States, especially those who are feeding themselves and/or food purists who may have some trepidation or doubts about the effects, if any, of pesticide residues, if any, on their health.

Perhaps energetically more important is companion planting of legumes and other nitrogen fixers as sources of nitrogen with high-yielding cereals like corn, Zea mays L., and sorghum, Sorghum spp. Many recent studies suggest that the companion nitrogen-fixer will add its own yield to subnormal, normal or supernormal yields of its counterpart, while adding nitrogen to the soil. Such companion plantings are not too practical in the energy-intensive American style of agriculture. But American's small farmers, especially in an energy crisis, might heed some of the intercropping lessions of the Third World. Nitrogen is energetically very expensive and many of our more important legumes are very good at "manufacturing" it. In some cases total food yields per acre are down slightly, but in many cases total yields are significantly improved via intercropping or rotation, and artificial nitrogen inputs are lowered significantly. A recent Furrow article suggests that more than half the nitrogen in America's crops already come from legume-fixed natural sources. Can't we improve on that, and save the large percentage of American energy that goes into the manufacture of artificial fertilizers? Broughton (3) showed that oil palms, Elaeis guineensis (Jacq.) intercropped with legumes yielded about 2 MT/ha more than those grown without legumes. Almost all crop and fodder legumes grown here in the United States fix nitrogen, so I will not enumerate them. I will list some of the herbs listed in the old wive's arsenal for biological control with some of the old wive's tales supported by analysis of the chemicals manufactured by the plant.

absinth: Artemisia absinthum L. discourages oviposition by cabbage butterflies (12).

aloe: extracts of Aloe barbadensis Mill. were toxic to Meloidogyne incognita and Rotylenchus reniformis (13).

ammi: essential oil of Trachyspermum ammi (L.) Sprague ex Turrill at 1% was more fungitoxic to Helminthosporium oryzae than some synthetic fungicides (23).

anise: Pimpinella anisum L. is said to repel insects.

basil: Ocimum basilicum L. is said to improve tomato in the garden and the kitchen; some gardeners use crushed basil as a spray to control beetles. Volatiles reduce germination and respiration of Fusarium spores.

black cumin: aroma said to repel certain insects; the essential oil from seeds of Nigella sativa L. is antinicrobial and anthelmintic (2).

brassica: Brassica spp. are said to repel certain insects and reduce disease (e.g. gram blight).

bugle: Ajuga reptans L. is said to be an effective insect repellent.

candytuft: ethanol extracts of Iberis amara L. showed 100% fungitoxicity against Helminthosporium oryzae and Cochliobolus miyabeanus (5).

caraway: Carum carvi L. is said to repel cockroaches; the essential oil from the seeds is toxic to the granary weevil (25).

catnip: Nepeta cataria L. is said to repel rats and attract cats (coincidence?), and to repel many insects (20 of 27 tested).

chamomile: Matricaria chamomilla L. is said to prevent disease and wilting in companion crops; more recently studied for antifungal effects (24).

chives: Allium schoenoprasum L. is said to repel aphids from adjacent lettuce, peas, and roses.

clover: Trifolium spp. sown between brussel sprouts, reduced infestation of Brevicoryne brassicae by over 80% (15); white clover between cabbage rows decreased eggs and larvae of cabbage root fly (21).

coriander: Coriandrum sativum L. is said to repel some garden insects; essential oil from the seeds is toxic to the granary weevil (25).

cornmint: essential oil of Mentha arvensis L. was active against Aspergillus flavus and A. fumigatus (22).

digitalis: digitalin works like nicotine on aphids and flea beetles, yet not so damaging to foliage; extracts of Digitalis grandflora Mill. inhibited several phytopathogenic fungi (4).

dill: sown annually in rows of grape (cv. Aligote) prevents the occurrence of the mildew Uncinula necator and removes the need for spraying (16); essential oil from seed toxic to granary weevil, but only 1/2 to 1/3 as toxic as malathion (25).

garlic: Allium sativum L. is said to repel insects (e.g. peach borer, cabbage worms), bacteria and snakes; garlic oil is said to be a specific for mosquito larvae.

geraniums (scented): species of Pelargonium are said to repel Japanese beetles.

greenbeans: Phaseolus vulgaris L., as a companion to potato, Solanum tuberosum L., is said to discourage potato beetles.

horseradish: as a companion to potato, Armoracia rusticana Gaertn., Mey. & Scherb., said to discourage potato beetles.

indigo: Field yields of cabbage, Brassica oleracea L., cucumber, Cucumis sativus L., and snapbean, Phaseolus vulgaris L., were significantly higher following a three-month cover crop of hairy indigo, Indigofera hirsuta L. This treatment was as effective or more effective than certain nematicida. treatments (18).

lavander cotton: Santolina spp., in small quantities, are said to kill herbarium insects.

leek: Allium ampeloprasum L., is said to discourage pests of cabbage.

lemongrass: Cymbopogon spp., repel many insects, which may also be repelled by other lemon-scented herbs; at concentration of 1%, essential oil of lemongrass is more toxic to Helminthosporium oryzae than some widely used synthetic fungicides (23).

leucaena: Mimosine from Leucaena leucocephala (Lam.) De Wit inhibits Colletotrichum lindemuthianum, Sclerotiun rolfsii, Cercospora canescens, Diploidia natalensis etc (8).

licorice: glycyrrhizic acid from Glycyrrhiza glabra L. inhibits the growth and cytopathology of several unrelated DNA and RNA viruses, and inactivates Herpes simplex virus particles irriversibly (17).

marigold: Tagetes erecta L. lowers nematode infestations in okra and orchards (14); said to repel bean beetles.

marjoram: volatiles produced by Origanum spp. lower germination and respiration of Fusarium fungus (1).

marijuana: Cannabis sativa L. is often planted around other Third-World crops to discourage insects (6).

meadowgrass: Poa annua L. is said to repel Colorado potato beetles.

mints: said to deter white cabbage moth and ants; menthol present in many species of the mint family (Lamiaceae), is said to be fungicidal (I have planted them around fence posts hoping that they will slow down decay fungi).

molasses grass: Melinis minutiflora Beauv. is said to repel some insects and ticks.

mothbean: Vigna aconitifolia (Jacq.) Marechal is said to reduce loss of cotton to root rot.

nasturtium: Tropaeolum majus L. is said to repel aphids (e.g. wooly aphids on apples), squashbugs, white fly, striped pumpkin beetles.

onion: Allium cepa L. discourages oviposition of cabbage butterflies (12); said to discourage fungi in the garden.

pennyroyal: Mentha pulegium L. is said to repel many insects.

peppermint: essential oil of Mentha x piperita L. was active against Aspergillus flavus and A. fumigatus (22).

periwinkle: alkaloids from Catharanthus roseus (L.) G. Don were active against Aspergillus fumigatus, A. ochraceus, Candida albicans, and C. utilis (20).

pumpkin: Cucurbita spp. shade out weeds when intercropped with corn and beans of the AmerIndian.

rosemary: Rosmarinus officinalis L. is said to discourage cabbage worm, bean beetle, carrot fly, and several other insects.

rue: Ruta graveolens L. is said to repel many insects; rue extract does repel Japanese beetle.

sage: Salvia officinalis L. discourages oviposition by cabbage butterflies (12); said to discourage carrot fly.

shoofly: a few plants of Nicandra physalodes (L.) Gaertn. scattered around a greenhouse are said to cause whitefly to disappear.

sorghum: roots of Sorghum spp. are said to be toxic to western corn rootworm larvae.

southernwood: Artemisia abrotanum L. discourages oviposition by cabbage butterflies (12).

soybean: Glycine max (L.) Merr. is said to shield corn from chinch bug.

spearmint: Mentha spicata L. is said to repel ants.

sweetflag: Acorus calamus L. is esteemed as an insect repellent and insecticide.

tansy: Tanacetum vulgare L. is said to repel ants and peach-tree borers, the powder is sometimes substituted for pyrethrum.

thyme: Thymus vulgaris L. discourages oviposition by cabbage butterflies (12).

tomato: Lycopersicon esculentum Mill. discourages oviposition by cabbage butteflies (12); said to repel asparagus beetles; tomato infusion used to control aphids in Belgium.

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APPLICATION OF NEW PROCESSING TECHNOLOGY TO SMALL FARMS

Donald D. Bills[1]

ABSTRACT

Work at the Eastern Regional Research Center has developed, over the years, a number of processing technologies of considerable value to small-scale producers of honey, cider, and maple sirup. Current work on plant materials includes the development of appropriate technologies for the small-scale handling and processing of fruits and vegetables, including edible sprouts. There are opportunities in small-scale processing for the family-size work unit, but a collective approach permits broader options. New, large-scale technologies have been developed, and some of these can be adapted to serve the needs of small farm operations. The products of small-scale manufacturers are most likely to succeed in the marketplace if the products project an image of "old-fashioned, farm-fresh" goodness combined with convenience. Competition with large food processing firms generally should be avoided by concentrating on items, such as regional or ethnic foods, that have a strong but geographically limited market and are of little interest to large companies.

Keywords: Food processing, small-scale farms, technology, appropriate technology, processing opportunities, collective approach, marketing.

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RESEARCH AT THE EASTERN REGIONAL RESEARCH CENTER

The potential economic benefits from involvement in processing operations are substantial. Only forty cents, on the average, of the consumer's food dollar goes to the farmer to pay for the raw commodities. The remaining sixty cents represents the value added to the food by processing, transportation, handling, and merchandising plus profit for each of the intermediaries between the farm gate and the consumer. For many processed foods, the value added after leaving the farm is much greater than the average. Roadside stands, pick-your-own operations, and farmer's markets shortcut ordinary marketing channels and yield a higher return to the farmer, but these outlets handle largely fresh, perishable produce, are seasonal and may require an inordinate amount of time to conduct the retail aspects. Small-scale processing provides an opportunity to market farm produce in other forms that can be even more profitable.

Work over the years at the Eastern Regional Research Center has yielded many new processing technologies that are of considerable value to operators of small farms. Although maple research is no longer active, new procedures for efficiently collecting and processing maple sap into sirup and other maple products were developed at ERRC--among them, methods for producing high-flavored, premium sirup; preventing the spoilage of sap through pasteurization with ultraviolet light or by chemical treatment; and removing the "buddy" off-flavor from sirup--as summarized in a USDA Handbook (12). Procedures for extending the shelf-life of fresh apple cider through pasteurization and/or the incorporation of sodium sorbate, a harmless food additive, were developed (3), and numerous requests are received for plans for the construction of a simple cider pasteurizer that can be assembled with a 55 gallon drum, aluminum tubing, and other parts from the hardware store. At a cost of slightly over $200, the homemade cider pasteurizer is an outstanding example of a piece of processing equipment that truly fits the needs and pocketbook of the individual small farm operator. Research on honey also has benefitted the many beekeepers in the United States, many of whom are operators of small farms and some of whom do their own processing and packaging of honey.

Currently, work at ERRC is being conducted to develop appropriate technologies for the small-scale processing of fruits and vegetables. One aspect of the work involves the development of a method that can be applied by the individual small farm operator for the production of cider-vinegar. Vinegar can be made from cull apples and also can be made from excess cider. The technology for large-scale vinegar production has made considerable progress, but the methods require scaling-down for small farm use. One of the problems involved in small-scale vinegar production is to develop an efficient, inexpensive, and low-energy-consuming means of aeration for the fermentation that forms acetic acid. A second problem involves the selection of a strain of yeast for the primary fermentation to form alcohol and a strain of the acetic acid-producing bacteria for the secondary fermentation of alcohol to acetic acid. Production of vinegar on a small-scale is nothing new, but it is not practiced to any extent anymore. There is an excellent possibility for the introduction of new technologies and microorganisms that are used by the large-scale, commercial industry.

Another line of research involves partial processing of products sold at farm stands or farmer's markets. The objective is to transform the raw products into a form more convenient for the consumer. For example, apples for use in pies or sauce could be peeled, cored, and sliced at the time of sale. Such partially-processed material must be stable enough to remain relatively unchanged until it is prepared in the home. In the case of apples, which begin to brown and deteriorate immediately after peeling, we have developed a treatment with common food additives that retards the deterioration of apple slices for several hours and results in pies that are equal to, if not superior, to those made from freshly prepared fruit. The market for fruits and vegetables that are partially processed at the point of sale for later preparation in the home is unknown, because consumers have never had this option. In view of the importance of convenience foods in supermarket sales, partial processing may have promise.

Information on recipes for canned foods comprising mixtures of low acid and high acid ingredients has been compiled in a data bank. From the statistical analysis of data obtained from determination of the pH of representative products, the pH of products containing various proportions of common ingredients now can be predicted. This capability enables the prediction of thermal processing procedures (boiling water temperature vs pressure canning) without actually formulating a product and measuring its pH, but does not replace the conventional means of physically determining pH and thermal processing parameters.

A final area of research involves the determination of appropriate small-scale conditions for producing edible sprouts. While the sprouts of seeds such as mung bean, soybean, and alfalfa are not traditionally produced by farmers, sprouts have a good and increasing market in restaurants, health food stores, and supermarkets, and there is no reason why some operators of small farms could not become involved in this endeavor. In addition to producing sprouts, operators of small farms also might consider producing seeds for sprouting in the home; bean seeds for sprouting sell at up to five times the price of dried beans for cooking.

TECHNICAL OBJECTIVES OF FOOD PROCESSING

The grand objective of food processing, like any other manufacturing industry, is to profit from the assembly and manipulation of raw materials. The technical objectives of food processing require some description here, however, since they are mainly quite different from those of most other industries. Food processing involves the manipulation of raw commodities to achieve one or more of three technical objectives: to assure the safety of the product, to change the form of the raw materials or to retard spoilage. Many foods are processed to achieve all three objectives in a single product. Processing operations range from the simplicity of washing raw potatoes before they are displayed for sale to the complexity of processing and bringing together the many ingredients in a package of cake mix. The first example involves just a minor change of form, from dirty to clean, but the second example involves processing to assure safety, to drastically alter the form of the raw materials, and to provide a product that will remain stable for many months on the shelf.

Pasteurization of dairy products is an example of a processing operation aimed primarily at assuring the safety of the products. Before the introduction of pasteurization, frequent outbreaks of milk-borne diseases were common. The number of people involved in an outbreak was small when families kept a single cow or a few cows to supply their own needs and, perhaps, to sell small amounts of milk to nearby neighbors. With the introduction of large-scale distribution procedures, several thousand persons became susceptible to contracting brucellosis from the consumption of raw milk from a single infected cow when that cow's milk was intermixed with the rest of the milk supply. The relatively mild heat treatment of pasteurization was introduced to assure that Brucella abortus (the bacterium responsible for the infection called brucellosis) and several other disease-causing microorganisms are totally destroyed before dairy products are consumed. Since pasteurization also destroys over 99% of the population of bacteria that cause the spoilage of raw milk, the shelf-life of properly-refrigerated pasteurized milk is extended by two weeks or more over that of raw milk. The extended shelf life is advantageous to distributors and consumers alike, but the primary objective of pasteurization is clearly safety.

Even when safety is not the primary objective of a food processing operation, it remains the single most important aspect of a processed food from the legal standpoint. An overwhelming portion of the body of food laws and enforcement activities deals with food safety, and the conditions for handling and processing food are stipulated rather rigidly by local, state, and federal governments. In considering how processing technologies can be adapted to benefit the operators of small farms, the legal requirements for equipment and facilities for handling and processing food for sale to the public are critical.

Changing the form of a raw food material is an outstanding way to add value through processing. There is hardly a way to improve the form of a juicy, dead-ripe peach--most of us would prefer to eat it out of hand or minimally process it by peeling, slicing, and serving with sugar and cream--but even this desirable fruit is consumed in many other forms, such as peach cobbler, jam, and as an ingredient in ice cream. Some unprocessed commodities have little value to the consumer--there is essentially no consumer market for wheat in the United States until it has been processed into flour, and flour sales to consumers are small compared to products that involve further processing such as pasta, baked goods, and cake mixes. Processing to change the form of raw materials must result in products that appeal to the consumer from the standpoints of appearance, flavor, convenience, and cost. Consumers also are influenced by nutritional quality and less tangible aspects, such as the "naturalness" of the food, the package, and advertising. The concept of making a food more convenient through processing operations conducted outside of the home or family unit is hardly new--millers have been grinding grains into flour or meal since antiquity--but the availability of a wide variety of foods that are ready to heat and serve is a relatively new concept. The U.S. potato industry, for example, has developed a wide array of convenience products--nearly 60% of the U.S. potato crop is converted into processed forms ranging from instant mashed potatoes to precooked French fries (5). The introduction of new technologies coupled with the changing lifestyles and perceptions of consumers has made possible the profitable marketing of highly-processed and, consequently, expensive and profitable convenience foods.

Processing to retard spoilage permits foods to be consumed at a later date and frequently at a distance from the point of production. Dehydro chilling of raw fruits and vegetables is a process aimed at delaying spoilage by a few days. Processes, such as freezing, that delay spoilage for many months or even years are called preservation. Foods are spoiled by the growth of bacteria, fungi and yeasts as well as by various chemical changes and mechanical damage. Because many chemical mechanisms of food spoilage require the presence of oxygen, exclusion of this gas or the addition of antioxidants is often part of the preservation process for certain products. Some chemical processes are promoted by enzymes that are naturally present in all raw food commodities, so preservation usually involves procedures that inactivate or retard the action of enzymes.

Although remarkable advances have been made in the technology of food preservation, no new basic principle for food preservation has been commercialized since 1810 when Appert published his treatise on canning (1,2). Drying, smoking, salting, pickling, fermenting, and chilling or freezing are ancient methods of food preservation that have been practiced since prehistoric times. All of these preservation procedures, including canning, originally were carried out without benefit of an understanding of why they worked. Only since 1864, when Louis Pasteur gave his report on microorganisms before the French Academy, has a systematic, though still incomplete, understanding of the scientific basis for food preservation been developed. In part because of the systemization of knowledge and in part due to other advances, great technical changes and improvements have been made in the application of the old methods of food preservation--for example, consider the impact of mechanical refrigeration vs the use of ice on the storage and movement of refrigerated foods in commerce. In determining how processing may contribute to the economic benefit of small farms, a prime consideration and researchable area is the scaling-down of sophisticated and complex technical processes for application by less centralized operations that may need to use more labor and less energy and machinery.

FAMILY-SIZE OPERATIONS

In considering operations that could be applied by an individual or a family-size work unit, there are three primary considerations: the cost of the processing equipment must be low, with the return equalling the investment in a very short period of time; operations and products must meet the minimum public health requirements; and there must be a reasonably predictable market for the products. These considerations restrict the range of possibilities for the individual small farm operator, since the equipment and facilities needed to comply with minimum legal requirements for many products are costly.

The processing of foods for sale by the individual small farm unit must be kept simple, and care must be taken to assure that the facilities, products, and licensing conform to local and state codes. If any of the product is to cross state lines, it also will fall under the jurisdiction of federal regulatory agencies. With a minimal, suitably equipped room, a small farm operator can consider, for example, processing operations that involve washing, sorting, and packaging fresh produce for sale to restaurants or retail outlets. Shelling and packaging dried beans, nuts, or sunflower seeds represents an opportunity for those who have an outlet in a farm market or can develop sales to retailers. The market for so-called health foods, natural foods, and organic foods may provide an outlet for dried seeds and nuts, especially if the farmer is willing to produce these "organically" without the use of pesticides and synthetic fertilizer. With a somewhat greater investment in equipment and facilities, the individual might consider a small milling operation to prepare specialty flours and meals for the health food trade. The production, processing, and packaging of honey is entirely possible for the individual entrepreneur and may provide income through the rental of beehives for pollination (in some areas) and the sale of honey. A USDA publication on beekeeping is available (11).

Fresh cider can be produced by orchardists without an extensive investment in equipment and facilities. Cull apples that are of little value can be transformed into thick, brown nectar that sells well in the autumn. Refrigeration is a necessity, though, because of the perishable nature of the product. A market for other fresh unclarified juices such as pear "cider" could be developed.

Many other possibilities for food processing operations of a scope similar to the above are within the reach of individual operators. The ambitious family might even consider marketing at least some of their farm production in the most highly processed form of all--the complete meal. The two most important requirements for opening a restaurant are a supply of good fresh food and culinary skill, and both are usually available on the farm. In Pennsylvania, many Philadelphians drive 50 or 60 miles to sample authentic Pennsylvania Dutch cooking in Lancaster County. Many of these restaurants had humble beginnings in a family operation. In Georgia, one successful country restaurant serves only catfish reared in a farm pond, hushpuppies, and French fried potatoes. The capitalization for even a modest restaurant is high, but the returns can be good. A location near a well-travelled highway or in a small town probably is necessary to succeed.

In addition to considering commercial operations, preservation of farm-produced food for consumption by the farm family deserves mentioning here. Home canning of even low-acid foods (e.g., corn, green beans, peppers, meat, and poultry) can be carried out in an inexpensive pressure cooker in the farm kitchen whereas a commercial operation legally would require an expensive retort equipped to monitor and record times and temperatures, a licensed operator, and other expensive equipment and facilities. With increasing food costs, the capability of producing and preserving much of their own food may be the most immediate way for families who live on small farms to improve their standards of living. Obviously many families do preserve food for their own use, but surveys indicate that considerable spoilage occurs due to the use of inadequate methods and that risk of botulism from the consumption of low-acid, home canned foods still stems from canning such foods in a boiling water bath, although this is a completely unacceptable and nonrecommended procedure. Educational efforts need to be directed to those who could benefit from an improved understanding of the procedures and scope of possibilities for preserving foods in the home. A number of USDA publications provide explicit instructions for canning, pickling, preserving, and drying foods for home consumption (6-10). Processing equipment of a scale between kitchen and commercial use for canning and making jams and jellies can be purchased by community groups. Such equipment can serve the collective needs of several dozen families in preserving food for their own use, but does not have the necessary features for processing food for sale to others.

COOPERATIVE PROCESSING

In order to afford to enter into more sophisticated food processing opportunities, operators of small farms need to develop cooperative or community enterprises. The concept of cooperative processing and distribution, wherein farm producers share in the profits (or losses), is hardly new. The history of dairying in the United States involves the formation of numerous large and small cooperatives (some of which remain successfully in business today) that took on the responsibility of receiving milk from the farmer members, transforming it into various products and distributing the products for sale. Obtaining sufficient capital to buy necessary equipment and facilities is a problem in these days of high interest rates, and it is absolutely essential to establish that there will be a reasonable market for products before any such business venture is undertaken. The shelves of retail food stores are full--any new brand or product line can be displayed only by displacing an item that is already on the shelves, and retailers are reluctant to stock too many brands of similar products. In order to gain entry, a new manufacturer's product must have uniqueness or cost and quality features that are highly appealing--retailers will not stock items that gather dust.

The most probable route to success for new cooperative ventures in food processing may well involve very small initial operations that manufacture high-quality foods that project an image of "down-on-the-farm" goodness. The initial outlets for the products may be limited to retail sales at the manufacturing facility itself, if it is well-located, and to retail outlets other than chain stores. In order to maximize return on the investment, the processing facility must be operated as many months of the year as possible. Obviously, the seasonality and perishability of the raw materials to be processed will control the length of the processing season. Meats, poultry, and milk are available in the fresh form throughout the year. Nuts, seeds, and grains are harvested during a short period, but after drying require no refrigeration and can form the basis for operations that extend throughout the year. Economical processing of fruits and vegetables usually requires the handling of several seasonal crops in a series, but a few crops such as potatoes, onions, and apples can be stored and processed over a period of many months. Some pickling operations are extended throughout the year by quickly brining the crop as it is harvested and then withdrawing the materials from brine for further processing as needed. Very few processing operations can be expected to function economically based on a single, highly perishable fruit or vegetable with a short harvest season. Refrigeration or freezing as a means of storing raw materials for later processing is costly and not applicable to many fruit and vegetable products that cannot tolerate the changes in texture caused by freezing. These limitations suggest that certain commodities may have great advantages over others in determining whether a profit can be made from small-scale, cooperative processing.

MARKETING OPPORTUNITIES

The best food products for introduction into the marketplace by small-scale industries may well be those that have a limited market. This sounds contradictory, but large companies cannot afford to diversify their production lines to manufacture a myriad of low-volume products. Regional and ethnic foods that might sell well in a very limited geographical area are of little interest to the large processor. According to David Robinette, president of Del Monte Sales Company, the U.S. canning industry is already scaled-up to operate at a capacity greater than needed (4). Consequently, a potential new small-scale processor should not consider canning sweet corn, for example, since this market is saturated by several highly-competitive giants of the food processing industry who depend on sheer volume rather than a large profit per case to stay in business. On the other hand, a good market has been developed by some very small, regional processors for products such as sausage and cured meats, ethnic foods, pickles, preserves, and specialty cheeses. In the northeastern United States, the maple industry, which is composed of many small-scale operators, continues to thrive despite outdated processing equipment and extremely high prices for maple sirup. In effect, there is a consumer demand for "old-fashioned" yet convenient products--many of which can be produced by 1981 technology.

It is not possible to recommend exact products that potential small-scale processors should consider. Opportunities will vary according to the raw materials that can be produced locally and the numbers and types of consumers near a given location. Proximity to an urban center provides better opportunities for sales through "health food" stores, restaurants, and farm markets than an isolated rural location. Any group considering entry into small-scale processing should consider test marketing a potential product before any attempt is made to raise capital for the purchase of equipment and facilities. This will require that some of the product be prepared to specifications by a custom processor at another location, and the processing, labeling, handling, and product must conform to all legal requirements. Test marketing will require a cash outlay, but it is preferable to sacrifice the cost of an unsuccessful test market trial than the capital involved in establishing a processing operation that ends in failure.

Consultation in the early stages of planning a small-scale processing operation is highly desirable and should begin at the time feasibility is being considered. Extension Specialists in Food Science at Land Grant Universities may be able to offer substantial assistance to potential small-scale food processors. Technical consultants also are available, but their fees are often high.

CONCLUSION

Establishment of a food processing operation requires the investment of capital and an associated risk, but neither of these is a stranger to the farmer. Many operators of small farms divide their time between farming and other employment off the farm. The cash returns from involvement in processing could exceed the income from other employment if the processing operation is selected and developed with care. However, specific knowledge of both the technical and legal aspects of commercial processing of food is absolutely necessary. From both the moral and legal standpoints, food products sold to the public must be safe. The liability, publicity, and cost of product recall surrounding a single outbreak of a food-borne illness have bankrupted some companies. An individual or group considering food processing as a way to generate income must take care to gain adequate knowledge about finance, facilities, equipment, and processes as the initial step.

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COMPOSTED SEWAGE SLUDGE, A POTENTIAL RESOURCE FOR SMALL FARMS

J. F. PARR [1] [2]

ABSTRACT

Sewage sludge compost is a valuable potential resource for small farms. Because of the increasing cost of chemical fertilizers, the agronomic value of sludge compost based on N-P-K alone now exceeds $25.00 per ton. If one considers the value of organic matter for improving soil physical properties in addition to the total nutrient content, the real value would be much higher. Sludge compost appears to have considerable potential for controlling soilborne plant diseases. Its application in agricultural and horticultural situations could provide new innovations for biological control or reduce the use of pesticides through integrated pest management systems. Sewage sludge compost has been used safely and economically in the formulation of potting media for the production of vegetable transplants which should provide small farms with the option of producing rather than purchasing their transplants. Intensive sequential production of vegetable crops is also greatly enhanced by proper use of sludge compost on marginal soils of small farms. Compost offers the opportunity for lower production inputs by reducing the amount of chemical fertilizer needed to sustain crop nutrient requirements. Finally, it has been demonstrated that the use of sewage sludge compost can restore sand and gravel spoils to a high level of agricultural productivity in as little as three years. Recommendations for future research with sewage sludge compost are discussed.

Keywords: Decomposition, disturbed lands, economic value of compost, manure, mineralization, organic amendments, plant pathogens, sewage sludge compost, soil productivity, soilborne diseases, small farms.

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Composting is an ancient agricultural practice whereby various organic wastes have been transformed into soil amendments and fertilizers that provide nutrients to crops and improve the tilth and productivity of soils. Composting is a microbiological process which facilitates the decomposition of organic wastes, the release of plant nutrients, the destruction of pathogens, and the abatement of malodors. If carefully managed the process yields a partially-stabilized humus-like residual organic material that can be highly beneficial for soil improvement and plant growth (10).

In the early 1970's municipalities throughout the United States faced a critically urgent problem of disposing of increased amounts of sewage sludge resulting from more stringent regulations imposed by the U. S. Environmental Protection Agency. Subsequently, the U. S. Department of Agriculture was asked to conduct research on composting as a means of stabilizing sewage sludges for use as soil amendments and fertilizers. In due course, the USDA at Beltsville, Maryland, in cooperation with the Maryland Environmental Service developed a rapid, aerobic/thermophilic composting process which is frequently referred to as the Beltsville Aerated Pile Method (16). The method has been widely adopted by both large and small municipalities in the U. S. and abroad as an environmentally-acceptable and economically-feasible alternative to ultimate disposal options such as incineration, landfill, and ocean dumping.

The macronutrient content of sewage sludge compost is rather low. As shown in Table 1, the N-P-K percentage analysis of compost produced from undigested sewage sludge at Beltsville is 1.3-1.5-0.2, respectively. Thus, it is unlikely that sewage sludge composts will be used to provide the total nutrient requirements of agricultural crops because of the large amounts that would have to be applied. The greatest potential value of these materials will be realized when used in combination with chemical fertilizers, thus providing partial fulfillment of a crop's nutrient requirements and a valuable organic resource for improving the tilth and productivity of soils. Table 1 also shows that sewage sludge composts can provide varying amounts of other essential plant nutrients such as calcium, iron, manganese, copper, and zinc.

The beneficial effects of sewage sludge compost on soil physical properties are many as evidenced by increased water infiltration, water holding capacity, water content, aeration and permeability, soil aggregation and rooting depth, by decreased soil crusting and runoff, and by lower bulk density (6, 17). USDA has also published recommendations for the use of sewage sludge compost for soil improvement and plant growth including (a) establishment, maintenance, and production of turfgrass and sod, (b) use in vegetable gardens, (c) production of field crops and forage grasses, (d) use on nursery crops and ornamentals, (e) use in potting mixes, and (f) reclamation and revegetation of disturbed lands. Specific recommendations are available as to time, methods, and rates of application of sewage sludge compost for different soils, crops, and management practices (6).

The purpose of this paper is to (a) discuss the potential value of sewage sludge compost for soil improvement and plant growth on small farms, (b) summarize the significant results from specific small farms research projects which have been part of this Laboratory's overall research effort during the past three years and (c) provide recommendations for future research on organic recycling that is relevant to the needs of small farms.

Table 1.--Chemical Analysis of Compost Produced from Undigested Sewage Sludge Obtained from the Blue Plains Waste Water Treatment Plant in Washington, D. C. Using Woodchips as a Bulking Material

COMPONENT	COMPOSITION
pH	7.3
Water, %	35
Organic Carbon, %	23
Total N, %	1.3
P, %	1.5
K, %	0.2
Ca, %	1.4
Fe, %	4.5
Zn, ppm	340
Cu, ppm	147
Cd, ppm	5.9
Ni, ppm	16
Mn, ppm	800
Pb, ppm	76

RESULTS AND DISCUSSION

Economic Value of Sewage Sludge Compost
(D. Colacicco and A. Barbarika)

Background and Objectives

Farmers everywhere have long-recognized the economic value of organic wastes for improving and maintaining the productivity of their soils. The economic value to the farmer of an organic waste such as sludge compost, is the value of the increase in crop production derived from its application, less any application costs the farmer must bear. The ultimate value per unit (e. g. pound, cubic yard, ton) of organic waste is whatever that particular unit of material contributes to the farmer's revenues. This is also the maximum price that a farmer would be willing to pay for a unit of organic waste. The objective of this research was to estimate the maximum price farmers would be willing to pay for a processed organic waste such as sewage sludge compost. It is well to point out that any reliable estimate of the economic value of sludge compost is critically dependent upon the availability of accurate and precise agronomic and climatic data relating the yield response of a crop to the application of sludge compost.

Results to Date

The most simplistic estimate of the value of sludge compost can be derived by estimating the value of the plant nutrients it contains. An implicit, but usually erroneous, assumption is that the increased crop yield from application of sludge compost is due exclusively to the associated plant nutrients. For example, if a particular sewage sludge compost contains 1.3 % N, 1.5 % P, and 0.2 % K, and the current market prices of N, P, and K were 30, 65, and 16 cents per pound, respectively, then the total value of the material would be $27.94 per ton.

Sewage sludge compost also contains other components that can contribute significantly to increased crop yields, such as organic matter, secondary and micronutrients, and sometimes lime. Some composts may contain unacceptable levels of ingredients that could adversely affect plant growth and yield, such as soluble salts, heavy metals, and toxic industrial organic chemicals.

Unlike most inorganic fertilizers, a substantial amount of the N and P contained in sewage sludge compost is not chemically available to plants during the first cropping season. Much of the unavailable N and P does become available with time. However, farm revenues generated by increased crop yields from release of nutrients at a later date, are worth less than the same revenues produced by an equivalent amount of nutrients released during the initial cropping season. This is because a dollar is worth more today than in the future. Thus, the value of plant nutrients released in the future must be discounted to obtain their present value. Experimental results obtained at Beltsville have consistently shown that the mineralization rate of organic N in sewage sludge compost applied to soil will release 10% of the total N the first year, 5% of that remaining for the second year, and 2% for each year thereafter. One can also assume that 60% of the total P is released the first year and 5% of that which remains for each year thereafter. It should be noted that certain amounts of the compost N and P may be lost from the system through irreversible fixation, leaching, erosion, and runoff. Approximately 100% of the K contained in sewage sludge compost would be available the first cropping season. It follows then that if a discount rate of 10% is used, the value of macronutrients in sewage sludge compost would be $17.61 per ton. It is readily apparent that accurate data on the time/rate of release of plant available nutrients from organic wastes, including sludge compost, are critical to this estimation procedure.

The economic value of sewage sludge compost to farmers depends on the crop to be grown, the expected crop revenue, soil type and its level of productivity, climatic factors, and other variables that affect crop response to sludge compost application. A logical approach to determining the value of a crop production input such as sludge compost, requires the development of a yield response function that relates crop yield to the particular input of interest and its substitutes. Crop yield response to sludge compost is not constant for all levels of compost applied, i.e. the increase in crop yield diminishes as the compost application rate is increased. Thus, the increase in crop yield is greater at low rates of compost than at higher rates, and the economic value per unit of compost to the farmer is correspondingly higher at low compost rates than at high rates.

The effect of sludge compost application on farm revenues can be thoroughly assessed using the aforementioned yield response function. The farmer will not utilize compost if the same yield effects can be obtained at lower costs with other inputs, such as chemical fertilizers. Obviously, any analysis of farm revenues affected by the application of sludge compost must necessarily include the price of chemical fertilizers as a reference point. Because the yield response function, and hence farm revenues, will vary with the crop grown, weather, soil type, and other variables, the analysis obtained will be valid for only those conditions that were specified.

Data from a one year experiment relating cabbage yields to the application rate of sewage sludge compost and fertilizer was used to derive a yield response function and analyze the resulting changes in farm revenue. The economic value of sludge compost, or the maximum price a farmer would be willing to pay for it, was determined to be about $20 per ton less $1.50 for every ton of compost applied (1). Thus, compost applied at a rate of 3 tons per acre would be worth $15.50 per ton. At a rate of 10 tons per acre the value of compost to the farmer falls to $5 per ton. It is well-known that the benefits derived from the application of an organic waste are not limited to the cropping season when they are applied but continue into the future, partially because of the time release of plant nutrients contained in the compost. Analyses of the crop yield and farm revenue response to organic wastes indicate that the cumulative discounted economic value of organic wastes applied to some agricultural soils could be as much as five times greater than the value realized during the application year (1).

Future Research Needs

In view of the specific nature of yield response functions, it would be desirable to analyze other sets of data involving different crops, climatic factors, soil conditions, and the residual effects of compost on yield. Experiments should be designed with the principal objective of providing the necessary data to fully evaluate the effect of these variables without the confounding influences that are inevitably found in experiments designed for other purposes.

Invariably, the economic value of organic wastes to be used for soil improvement and plant growth is based exclusively on their content of the macronutrients N, P, and K. It is conceivable that in some soils the organic matter component, and its profoundly beneficial effect on improving soil physical properties, could be assessed a greater economic value than the macronutrient content. While the beneficial effects of organic matter on soil productivity are well-known, it is extremely difficult in the case of a particular organic waste to separate the crop yield effects due to organic matter from those due to the plant nutrient content. Experimental procedures and special data analysis techniques should be thoroughly explored so that the economic value of the organic component in different kinds of organic wastes could be accurately and meaningfully estimated. This should be done for a number of different crops, soils, management systems, and climatic situations. Such data could greatly stimulate the use of organic waste on agricultural land for control of soil erosion and nutrient runoff, and to improve soil productivity.

Sewage Sludge Compost as an Amendment for Control of Soilborne Plant Diseases

(R. A. Lumsden, J. A. Lewis, and P. D. Millner)

Background and Objectives

In recent years, biological control has emerged as a potential means of reducing the incidence of diseases. The success of this approach depends on the enhancement of antagonistic biological activities. With regard to soilborne pathogens, the antagonistic biologically-mediated activities include antibiosis (the production of antifungal growth inhibitors by nonpathogenic microorganisms or plant roots), nutrient competition (increased competition for essential metabolic components by pathogens, nonpathogens and plants), and parasitism (pathogens are parasitically attacked and destroyed by nonpathogens). One way in which these activities are stimulated is through enhanced soil microbial activity which accompanies the biological decomposition of organic materials in soil. Amending soils with farm manure, straws, and green manures has often contributed to the control of certain soilborne plant diseases (2). The availability of sewage sludge compost for land application and horticultural use (6, 11) coupled with the concepts of biological control suggested the need for information on the potential use of sewage sludge compost as an amendment for control of soilborne diseases.

Results to Date

A greenhouse pot study involving a number of pathogen-infested soils was conducted to evaluate the effectiveness of sewage sludge compost as an amendment in the control of soilborne diseases. Soils were either unamended or amended with dry compost at a rate of 10% (w/w). A basal fertilizer (10-10-10) application was applied to all pots. Results of this study (9) in which optimal conditions for disease development were maintained, are shown in Table 2. The application of sewage sludge compost produced a significant decrease in disease for (a) lettuce leaf-drop caused by *Sclerotinia minor*, (b) root-rot and damping-off of bean, cotton, and radish caused by *Rhizoctonia solani*, (c) root-rot of peas caused by *Aphamomyces euteiches*, and (d) root-rot of peppers caused by *Phytophthora capsici*. Responses of the five other host-disease complexes to the compost amendment showed either no change or increased incidence.

Table 2.--Effect of sewage sludge compost on diseases caused by nine soilborne pathogens as determined in greenhouse pot assays.

		DISEASE (%)[1]	
PATHOGEN	HOST	UNAMENDED	COMPOST AMENDED
Aphanomyces euteiches	pea-Alaska	43	3*[2]
	pea-Perfected Freezer	48	10
Rhizoctonia solani	bean-Blue Lake	63	25*
	cotton-Stoneville	88	60*
	radish-Scarlet Globe	88	32*
Sclerotinia minor	lettuce-Parris White	84	33*
	lettuce-Boston	91	50*
Phytophthora capsici	pepper-California Wonder	97	55*
Pythium ultimum	pea-Alaska	39*	68
Thielaviopsis basicola	bean-Blue Lake	36*	84
	cotton-Stoneville	49*	79
Fusarium solani	pea-Alaska	33	40
	pea-Perfected Freezer	65	55
Pythium aphanidermatum	bean-Blue Lake	14	12
Pythium ultimum	pea-Perfected Freezer	97	94

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[1] Disease parameters based on root rot severity (0 to 100) for *Aphanomyces*, *Rhizoctonia*, and *Fusarium*, and on diseased plants (%) for *Sclerotinia*, *Phytophthora*, *Pythium*, and *Thielaviopsis*.

[2] * indicates % disease significantly less than the alternative treatment, P=0.05.

Field trials on the effects of sewage sludge compost on damping-off of pea and cotton by *Pythium* and *Rhizoctonia*, and on leaf-drop of *lettuce* by *Sclerotinia* were conducted at Beltsville. In 1980 and 1981, compost was spring-applied to one-half of the plots (2.5 x 4.0 m) at a rate of 100 tons per acre and rotovated into the soil to a 15-cm depth. Control plots were supplemented with fertilizer (10-10-10) and limestone to attain a plant nutrient and pH level that was comparable to the compost-amended plots. Two fungicides, thiram and PCNB, were added as seed treatments in plots treated with either compost or fertilizer. Soils were artificially infested with the fungal pathogens, *Rhizoctonia* and *Sclerotinia*, and naturally infested with *Pythium*.

Table 3 shows that a significant decrease in diseased plants occurred each year in the compost-amended plots compared with the control plots receiving only fertilizer and lime. Interestingly, the effect of compost is one of disease suppression rather than reduction of pathogen propagules. Soil and microbial factors that might be involved in disease suppression were measured. In the compost-amended soils infested with *Sclerotinia* and *Rhizoctonia* it was noted that the pH, moisture content, total P and Cu were significantly higher than in the control (fertilizer-treated) plots. Moreover, the *Sclerotinia*-infested soil amended with compost had higher levels of NO_3-N and Mg than the unamended controls. The independent effects of these factors on disease expression is not known and must be evaluated before any conclusions can be drawn concerning their importance in the observed disease-suppression effect.

A rather surprising result in this study was the apparent interaction of compost and the two fungicides, thiram and PCNB. Disease suppression was greater for both the compost and fertilizer treatments when seed treatment was included, and considerably so with compost. This particular effect also appeared to continue with time. The exact basis for the increased level of disease control should be thoroughly investigated.

Table 3. Effect of sewage sludge compost on damping-off of pea and cotton by *Pythium* and *Rhizoctonia*, and on leaf drop of *lettuce* by *Sclerotinia* in the field. Where indicated, thiram and PCNB were added as seed treatments in plots receiving either fertilizer or compost.

DISEASE/ TREATMENT	HEALTHY PLANTS (%) SPRING 1980*	 FALL 1980*	 SPRING 1981*
Pea damping-off			
Fertilizer	11 a	12 ab	0 a
+ thiram **	30 b	33 bc	0 a
+ PCNB	37 bc	27 ab	2 a
Compost	17 ab	29 abc	24 b
+thiram	39 bc	54 d	58 c
+PCNB	48 c	46 cd	73 d
Lettuce leaf drop			
Fertilizer	30 a	76 a	86 a
Compost	50 b	88 b	97 b
Cotton damping-off	SUMMER 1980		SUMMER 1981
Fertilizer	9 a		32 a
+ thiram	30 b		67 b
+ PCNB	29 b		--
Compost	24 ab		30 a
+ thiram	49 c		71 b
+ PCNB	60 c		--

* Values in each column for each disease followed by the same letter do not significantly differ, P=0.05.

** + thiram and + PCNB (pentachloronitrobenzene) indicates seed treatment; no + indicates no seed treatment.

Future Research Needs

The central question concerning the control or suppression of certain plant diseases after amending pathogen-infested soils with sewage sludge compost remains unanswered -- What is the precise mechanism(s) of control? Is it biologically-mediated by the soil microflora after modification by the compost, by the compost microflora, or by some combination of both? Results have shown that significantly higher populations (and probably with greater physiological diversity) of actinomycetes, bacteria, and fungi occur in compost-amended than in unamended soils. Certainly, this suggests that a greater level of microbial activity occurs in compost-amended soils, but it doesn't necessarily mean that disease control is biologically-mediated. It is entirely possible that control is achieved by some direct or indirect microbial response to soil physico-chemical characteristics. It is important to understand the basis for control so that the composting process will ensure the production of uniform and effective products. A scope of research is urgently needed to answer these and other questions relating to the disease control properties of sewage sludge compost.

Sewage Sludge Compost as a Growing Media for Horticultural Crops

(S. B. Sterrett and R. L. Chaney)

Background and Objectives

Operators of small farms can usually profit by growing their own transplants for high value crops. They have traditionally used "peat-lite" media for this purpose; however, the cost of peat, vermiculite, and perlite have risen sharply in recent years. Product quality and availability are also of concern. Alternative media are needed. Recently, Chaney et al. (3)

reported that composted digested sewage sludge was an effective ingredient for potting media for marigolds when supplemental N was supplied from chemical sources. Both peat and sludge compost provide acceptable amounts of organic matter for potting media; however, sludge compost contains substantial amounts of essential plant nutrients (Table 1) while peat is essentially a sterile product which is considerably more expensive than sludge compost. Thus, sludge compost is an attractive candidate for use as a organic component in the preparation of potting media.

The heavy metal content of various sewage sludges will probably determine to what extent sewage sludge composts are used in potting media. In the case of non-edible horticultural crops, heavy metal accumulation is of little concern, provided that plant growth and development are not adversely affected. However, in the production of vegetable transplants, the resulting heavy metal content of edible portions must be considered. The objective of this study was to determine whether sewage sludge compost could be used safely and beneficially as an organic component in potting media for the production of vegetable transplants.

Results to Date

An experiment was conducted to compare quality, heavy metal accumulation, and yield of transplants grown in a peat-vermiculite media (P:V) or in media containing 1 or 2 parts (by volume) of a low-metal compost produced from residential sewage sludge (LM), and a high-metal compost produced from sewage sludge contaminated by industrial sources (HM). As shown in Figure 1, there was little difference in the dry weight yields of tomato and cabbage when grown in the P:V or LM media, even when formulated with 2 parts of LM compost. Dry weight of transplants were significantly lower when grown in the media containing HM compost, particularly with 2 parts of HM compost in the formulation. It is apparent that dry weight was adversely affected by the excessive metal content of the HM compost. Nevertheless, when transplants grown in either P:V or LM media, or in HM compost media containing 1 part compost, were planted in field plots and grown to edible maturity, there were no significant yield differences for tomato, muskmelon, or cabbage in two consecutive years (13).

Metal concentrations (Zn, Ni, and Cd) were highest in transplants grown in HM media; however, after they were field transplanted and grown to maturity there was no significant difference in the metal content of edible portions (i.e. cabbage heads, tomato, and muskmelon fruit) compared with the other media (12). There was little difference in the metal content of transplants grown in either P:V or LM media.

This study indicates that good quality transplants can be safely grown in low-metal compost media without adversely affecting crop

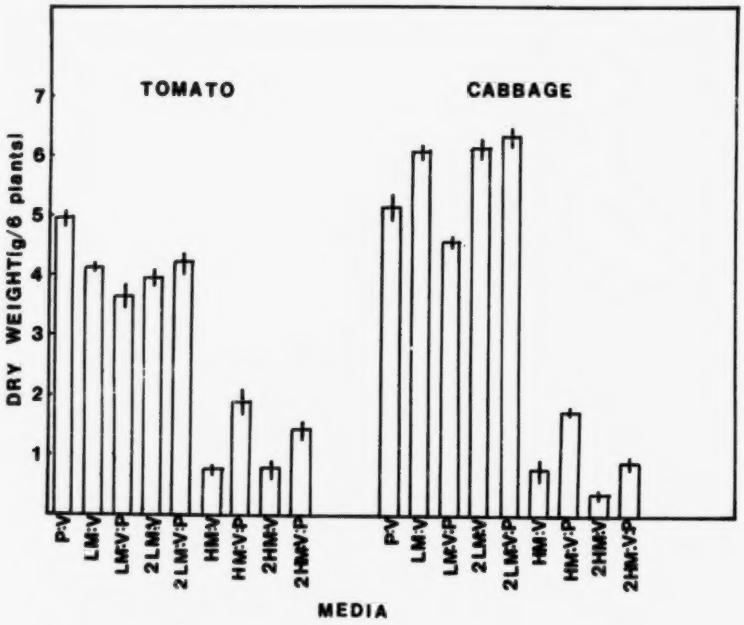

Fig. 1. Dry weight of tomato and cabbage transplants grown in peat:vermiculite (P:V) or media containing 1 or 2 parts (by vol.) low metal (LM) or high metal (HM) compost, vermiculite (V), with or without peat moss (P).

yields after transplanting or increasing the metal content of edible portions. Sewage sludge composts with excessive concentrations of heavy metals are not recommended for use in vegetable transplant media because of possible adverse effects on transplant quality.

Future Research Needs

Additional work is needed to evaluate the influence of compost media on the maintenance of transplant quality, both for field plantings on small farms and in retail markets where transplants and bedding plants are held for some time before sale. Another area of interest is in the growth of bedding plants and transplants in cell packs which are popular for retail sales. Since the media volume is very limited, studies on plant growth in compartment-type bedding plant containers are needed before specific recommendations can be made to the growers.

Potting media used in greenhouse propagation of plants frequently contain peat or peat products which have been found to harbor plant pathogenic Pythium and Fusarium species even in products labelled as "sterilized" (8). Because of the thermophilic temperatures attained during the composting process, sewage sludge compost contains neither of these genera. Thus, the use of sewage sludge compost in place of peat-based products offers an opportunity to eliminate a possible source of infection. Future research on the effect of various potting media on transplant quality in the retail market as affected by time and storage conditions, should necessarily involve the services of a plant pathologist. The relative incidence of plant diseases associated with different media, particularly under stressful conditions of moisture, temperature, and root confinement, should be thoroughly assessed.

Optimization of Vegetable Production on Small Farms with Organic Amendments

(C. F. Tester, L. J. Sikora, and J. F. Parr)

Background and Objectives

Many of the soils associated with small farms are considered to be of low or marginal productivity because of certain deficiencies involving poor soil texture (i.e. extremes of sand or clay) and low organic matter. Small farms often lack the capacity to support a sufficient number of animal units to provide enough manure for soil improvement, and many farmers cannot afford the high cost of chemical fertilizers as a serious production input. For some farmers off-farm sources of organic matter in the form of animal manures and sewage sludge are still economically acceptable inputs for improving the productivity, tilth and fertility of their soils

The purpose of this study was to optimize the production of vegetable crops on marginal soils that might be found on small farms in the Northeastern U. S. using several organic amendments, i.e. sewage sludge compost and animal manure, as a source of plant nutrients compared with chemical fertilizers. A substantial amount of basic research had been conducted earlier to determine the rate of mineralization and release of N, P, and S in soils amended with sewage sludge compost (14, 15).

Results to Date

A field study was conducted in which sewage sludge compost at rates of 30, 60, 120, and 240 metric tons/ha and beef manure at 65 and 130 metric tons/ha (both on a dry weight basis) were applied to different plots of a marginal soil and incorporated to a 15-cm depth. Nitrogen fertilizer was added to the "fertilized plots" at rates of 0, 34, 67, and 101 kg/ha along with basal quantities of P, K, and B. Sequential cropping was conducted to demonstrate the potential for maximizing land use and production. Thus, early cabbage was followed with tomatoes, which in turn was followed with cauliflower on the same plot each year. Both the yield and quality of crops were carefully evaluated for all treatments. The two organic amendments were applied at the indicated rates once each year just prior to transplanting the cabbage crop. Nitrogen, P, K, and B fertilizer was applied at the indicated rates three times per year, i.e. just prior to planting of each crop. Earlier research has shown that approximately 10% of the total compost N would be available for crop uptake during the first season, while at least 20% of the manure N would be plant available.

Results of this study are shown in Table 4. The addition of both compost and manure resulted in significantly greater cabbage yields than the fertilizer treatments. The highest compost rate appeared to delay the maturity of the cabbage, possibly the result of excessive amounts of N and/or soluble salts. Tomato yields in 1979 were considerably higher for both amendments than for the fertilizer treatments, except for the 30 mt/ha rate of compost which was essentially the same as the 0 fertilizer rate. This would indicate that most of the available N from the low compost rate had been utilized by the earlier cabbage crop, and that very little residual inorganic N was present. The same observation can be made for the low yield response of the 1979 cauliflower crop to the 30 and 60 mt/ha rates of compost. Although cauliflower yields increased at higher compost rates, they were considerably lower than the yields attained at the higher rates of fertilizer N and manure. This would suggest that the application of some supplemental N fertilizer would be essential to ensure optimum yield of the third crop in such an intensive sequence as followed here, at least when using sewage sludge compost as an organic amendment.

There was a substantial yield increase for cabbage from fertilizer in 1980 compared to the

Table 4.--Vegetable Yield Response to Sewage Sludge Compost, Beef Manure, and Fertilizer N Additions to an Infertile Soil.

TREATMENT	CABBAGE 1979	TOMATO 1979	CAULI-FLOWER 1979	CABBAGE 1980	TOMATO 1980
Fertilizer N (kg/ha)					
0	349	44.5	2894	524	28.5
34	457	50.8	3361	622	40.4
67	578	54.2	5088	788	42.5
101	577	63.9	5855	900	52.0
Compost (metric ton/ha)					
30	720	45.7	2348	686	25.4
60	820	61.5	2666	713	41.3
120	863	70.0	3483	905	59.8
240	791	112.4	4676	1017	63.0
Manure (metric ton/ha)					
65	612	86.5	5837	862	46.4
130	755	113.7	5827	741	48.0

Cabbage yields are based on the mean head weight in grams.

Tomato yields are based on the mean plot yield in kilograms.

Cauliflower yields are based on mean plot (harvested area) yield in grams.

1979 yields. This could be the result of significant carry over of residual N from four successive applications. The reapplication of compost and manure in 1980 resulted in cabbage yields that were comparable to those of 1979, except for the unusually high yield at the 240 mt/ha rate of compost. Tomato yields for 1980 were considerably less than in 1979, probably the result of an extended drought during the growing season. As in the first year, the low rate of compost could not keep pace with the crop's demand for available N.

Future Research Needs

These data suggest that three vegetable crops can easily be produced on well-drained marginal soils at this latitude each year and that organic amendments such as manure and sewage sludge compost can be used to provide a substantial amount of the fertilizer requirement. However, the data indicate that when sewage sludge compost is used in such an intensive production sequence, it will be necessary to apply some supplemental fertilizer N. Research is urgently needed to determine the most practical and workable combinations of sewage sludge compost and chemical fertilizers needed for different crop and soil management systems. The economic aspects of such an effort should be thoroughly investigated.

Small farms would greatly benefit from research to determine the most effective and efficient ways to apply compost to crops and soils. For example, as composts increase in value we should investigate specific placement methods such as banding or side-dressing to effectively modify soil characteristics and enhance plant growth. Research should also be directed toward ways and means of producing sewage sludge composts with a higher N content. This might be accomplished through enrichment techniques using other organic wastes of a higher N content or simply blending in fertilizer N.

Restoring Soil Productivity on Disturbed Lands with Organic Amendments

(S. B. Hornick)

Background and Objectives

Many small farms or potential small farms partially comprise areas that were once mined for sand and gravel. These disturbed areas are typified by a lack of vegetation due to almost total absence of soil and organic matter, and the extremely low levels of macronutrients (especially N, P, K, Mg, Ca, and S) and micronutrients (Cu, B, Zn, Mn, and Mo) that are essential for plant growth. Severe erosion has generally occurred which impedes water infiltration and retention and hence root development and plant growth.

An additional complication is that these disturbed areas often contain large pieces of asphalt, concrete, or other debris which restricts root growth and water movement because of the very heterogeneous soil profile.

Studies have shown that sewage sludge compost can promote the establishment of forage crops on acid strip mine spoils (4). Often when such marginal or disturbed lands are amended with sludge compost, the resulting vegetative growth is greater than that of the control areas (5). This response is attributed to the improvement of soil (spoil) physical properties, the buffering effect of organic matter, increased pH from lime contained in compost, and the array of plant nutrients provided by the compost (Table 1). If sand and gravel spoils could be restored to a high level of agricultural productivity, the economic status of many small farmers would be vastly improved. The purpose of this study was to determine the potential value of sewage sludge compost and animal manure in restoring such lands to an acceptable level of productivity.

Results to Date

In 1979 and 1980, field plots were established on a sand and gravel spoil site which was shown to be acidic and extremely low in basic soil fertility and organic matter. To determine the feasibility of growing agronomic crops on such infertile media, sludge compost and feedlot manure were applied to plots at rates of 0, 40, 80, and 160 mt/ha and then planted to field corn, sweet corn, and bush beans. The control plots (0 mt/ha of either amendment) were limed and fertilized with N, P, K, at a rate recommended for optimum crop production. Plots receiving 40 and 80 mt/ha of compost or manure were supplemented with fertilizer N, equal to that applied to the control plots.

The application of either sewage sludge compost or feedlot manure to the sand and gravel site resulted in dramatic yield increases of corn and bush bean over those of the fertilized controls, but especially for the compost as shown in Table 5 (7). Compost additions also greatly increased the number of beans per plant. Besides the beneficial effects from their plant nutrient and organic matter content, both amendments were found to significantly lower the surface and subsurface soil temperatures and to increase soil moisture content and moisture retention. The amendments also reduced the rate of soil drying. In effect, the amendments created a more favorable environment for seed germination and root development.

Table 5.--Crop yield reponse to sewage sludge compost applied to a sand and gravel spoil site.

SLUDGE COMPOST APPLIED (mt/ha)	FIELD CORN STALKS (kg/ha)	BUSH BEAN PODS (kg/ha)
0	6092	878
40	--	1175
80	6819	1309
160	7952	--

This study has shown that severely disturbed lands can be restored to a high level of agricultural productivity by the proper use of organic wastes, especially sewage sludge compost, within a relatively short period of time, i.e. 3 to 5 years.

To prevent ground water pollution from nitrates and chlorides contained in some wastes, the waste application rate should be determined by the waste composition, the type of crop to be grown, and the spoil texture. As long as low metal wastes are used and soil or spoil pH is maintained near 6.5, trace metal uptake in food chain crops should not be significant.

Future Research Needs

One of the biggest concerns in the reclamation of gravel spoils using organic amendments is what mode/method of application to select for the most effective and shortest period of restoration. Studies on incorporation techniques such as (a) rototilling, (b) disking, and (c) vertical mulching, i.e. a subsoiling operation with sludge compost incorporated into the channel before closure, were evaluated as to the effect on crop yield and quality. Excellent results were obtained with the vertical mulching, a method which places compost to a depth of more than 30 cm and modifies the spoil profile which in turn facilitates root development and interception of runoff. The reclamation process on such spoil material may be considerably enhanced by using vertical mulching the first year for compost application and the incorporation by disking in subsequent years. In addition to the mode/method of application, research is needed on management factors involving the time, rate, and frequency of compost application, and the soil, cropping sequence, and tillage system. A better understanding of how these factors interact should provide a more reliable basis for effective use of sewage sludge compost in gravel spoil reclamation.

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GREENHOUSE PRODUCTION OF VEGETABLE PLANTS

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ABSTRACT

Research and grower experiences have demonstrated the economic feasibility of greenhouse vegetable plant production. Many market gardeners, particularly in the Northeastern United States where growing seasons are short and land values high, have greenhouses for growing vegetable transplants. This practice should be part of a total program utilizing improved cultivars, advanced field production technology, and marketing high quality produce.

Keywords: Small scale farms, vegetable transplants, greenhouses.

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For many small and part-time farmers, a greenhouse may provide a practical means to increase income. Before deciding to buy or build a greenhouse, each person should carefully analyze his operation to determine if there is economic justification for a greenhouse. Furthermore, there must be someone who can be near the greenhouse at all times when it is being used for plant growing in case of equipment failure. Usually it is best to have one responsible family member that has an interest in greenhouse plant growing assume the major responsibility. Proper greenhouse management requires considerable knowledge and skills. Before building a greenhouse, the person(s) responsible for it should receive some training, read available publications, and consult with cooperative extension personnel regarding greenhouse operation. Situations where a greenhouse has proved practical for many small and part time farmers have included:

1. Families with members who, because of age or other reasons cannot obtain outside employment, but who can contribute toward family income by managing a greenhouse.
2. A greenhouse will increase the length of time family members may be gainfully employed.
3. The farmer can grow his own transplants, assuring availability of quality plants of desired cultivars when needed.
4. Often local markets exist where plants may be sold. This provides cash early in the growing season before field plantings are providing cash return. This is very important in view of the current high interest rates charged on loans.
5. A greenhouse often serves as a nucleus or focal point to build a roadside or farmers market around. Many successful growers begin their marketing season with sales of hardy vegetable transplants, and continue into spring with other vegetable and annual flowering plant sales. As the season progresses sales will include home grown vegetables, many being produced from the farmer's own greenhouse grown vegetable plants. During the fall and early winter, it might be practical for the farmer to consider greenhouse grown vegetables, such as cucumbers, lettuce, and tomatoes. This kind of production requires considerable knowledge and management ability, and is not recommended for the beginning greenhouse owner.

There are no doubt other situations that would justify the small and part-time farmer having a greenhouse. Likewise, there are many situations where it would be unwise to invest in a greenhouse. Each situation is different, and each person considering a greenhouse should thoroughly evaluate the pros and cons of such an investment.

Type of Structures

There are many kinds and sizes of plant growing structures available. The simplest to construct is the cold frame with removable sash covering. It is very difficult to grow high quality plants in this type of structure. These may be used for holding or "hardening" some types of transplants but are not recommended as the only structure for growing transplants.

Of the many commercially available greenhouses, the quonset type with bent pipe framing is probably the most practical of the free standing greenhouses. These are usually available, complete with heating and ventilating equipment, thermostats, and air inflation kit for double-layer, air-separated plastic covering. Most farmers with available tools and some basic knowledge of construction technique can erect a greenhouse of this type. It is important that the greenhouse be equipped with automatic controls for heating and ventilation, and that energy saving techniques such as double plastic covering and thermal shields be used. Also, the capacity of the heating and ventilating equipment should be adequate for expected climatic conditions. The grower should only purchase what is actually needed, but should not try to cut costs by elimating some of the required equipment. Most reputable greenhouse and greenhouse equipment companies have qualified persons that can advise on required equipment and construction requirements.

Greenhouse Site Selection

Very careful consideration should be given to where the greenhouse is located. Some of these are as follows:

1. Locate where trees or other obstructions will not block sunlight during the short days of winter and spring.
2. Where possible, location should be such as to take advantage of any type of windbreaks on the side of prevailing winds during cold weather.
3. Location should be readily accessible adverse weather by workers, fuel delivery vehicles, etc.
4. Location should be convenient to water and electricity supply.
5. In most locations an east-west orientation would probably be preferred. This provides a greater amount of surface at a favorable angle of incidence to sunlight than is possible with a north-south orientation.
6. Where space is available for several greenhouses to be built, the first greenhouse to be constructed should be located where orderly expansion is possible, in case the need for additional greenhouses arises.

7. If a greenhouse is used in conjunction with a roadside market, it should be located convenient to the market. Some growers use a greenhouse for part of their display area; others do not want to open their greenhouses to the general public. At any rate, an attractive greenhouse near the sales area can be an added incentive for customers to stop at the market.

Plant Growing Media:

During the past decade or so "soilless" media have become very popular with greenhouse growers. These are usually made up of various combinations of peat moss, vermiculite, perlite and milled pine bark. These may be purchased as ready to use mixes, or separate ingredients obtained and mixed by the greenhouse grower. It is probably more practical for most small greenhouse owners to purchase ready to use media unless one or more locally available media components can be obtained at a considerable cost savings over commercial mixes. In some areas milled pine bark in particle sizes that will pass through 1/2 x 1/2 inch mesh screen is available. Results from research with composted sewage sludge (2) has shown that sludge that is low in heavy metals may be incorporated in transplant growing media.

Many of the commercial soilless media contains peat moss, vermiculite, and various combination plant nutrients. Some have very low levels of fertilizer, especially nitrogen, since many growers like to liquid feed as the plants grow. One combination that has produced satisfactory transplants is given in Table I.

Table 1. Ingredients of peat-vermiculite medium used by many greenhouse plant growers.

Quantity		Ingredient
35 dm^3	(1 bu)	sphagnum peat moss
35 dm^3	(1 bu)	horticultural grade vermiculite
454 g	(1 lb)	dolomitic lime (finely ground)
113 g	(4 oz)	superphosphate (0-20-0)
57 g	(2 oz)	calcium nitrate (15.5-0-0)
198 g	(7 oz)	calcium sulfate (gypsum)
7.8 g	(.25 oz)	fritted trace elements (FTE 503)

Note: Where available, milled pine bark from any species of southern pine, screened through 1/2" x 1/2" mesh may be substituted for peat moss.

The addition of a slow release fertilizer at rates recommended by the manufacturer will continue to provide mineral nutrition for transplants after field setting. The vine crops (cucurbits) are sensitive to exess fertilizer and nutrient levels should not exceed those given in Table I.

The use of topsoil, sand and manure in plant growing media should be avoided unless the grower has equipment to steam treat for control of weed seeds and diseases. There is also the risk that harmful herbicide residues may be in top soil.

Vegetables for Transplanting

Vegetables are generally classified as being either warm season or cold season, depending on tolerance to cold weather. One primary benefit to vegetable growers from growing their own plants is likely to be earlier and increased crop yields. Therefore, logical warm season vegetables would be those such as tomato, eggplant, pepper, muskmelon, watermelon, and cucumber.

Seeding

Media for seed germination, especially small seeds, should be finer textured than is necessary for growing the transplant. Seeds of crops such as tomatoes, pepper, and eggplant are usually planted in rows, 8 - 10 seeds per linear inch, and covered to about 1/4 inch depth. Larger seeded crops such as the vine crops are best seeded directly into the container used to grow to field transplanting size. Commercial peat pellets and peat pots are satisfactory for this.

Seed germination is usually hastened at temperatures 5 - 10°F higher than the optimum temperature for growing plants. As soon as seedlings emerge they should be exposed to full light and grown at a reduced temperature.

Plants growing in seed flats should be transplanted to individual containers for growing on while at the cotyledon (seed leaf) stage of development.

Transplant container size should be at least 2 1/4 x 2 1/4 inches for all crops except the vine crops where the somewhat smaller compressed peat pellet is satisfactory. The main thing to remember is that the plants should be field set before they grow too large for the container. Vine crops should be field set when the second true leaf is about 2 inches in diameter. Tomato, pepper, and eggplant transplants grown in 2 1/4 x 2 1/4 inch pots should be field set when 6 - 8 inches tall and before any flowers have opened. Some farmers grow these crops in larger containers and do not transplant in the field until after flowers have opened, and in some instances after fruit have set. For this to be successful, the grower should have nearly optimum conditions with respect to soil nutrients and moisture, as well as a favorable growing temperature and protection from damaging winds.

The best transplant should have the proper ratio of roots to vegetative development. These should be further developed if flowers have opened or fruit has set. This is why bare root transplants or those grown in small pots that have fruit set at the time of field setting usually do poorly.

Greenhouse Management

A mistake many inexperienced greenhouse owners make is trying to maintain greenhouse air temperature too high. Maintaining temperature at levels higher than needed for good plant growth not only results in excessive fuel costs, but also may result in poor quality transplants. The person managing the greenhouse should know what day and night temperatures are required and set heating and ventilation controls to maintain, as near as possible, these levels.

Proper water management for plants is often difficult to achieve. Many factors, including growing medium, plant size, day length, and weather conditions, will influence the daily water requirements of plants. Learning accepted techniques for watering and being observant of results obtained are necessary for success. Probably the most critical time during plant growing to be especially careful is when watering seed flats and newly transplanted seedlings. Fine mist spray nozzles are usually required to prevent overwatering and washing or compaction of the medium. As plants grow larger and days become longer, water requirements increase, and it is not so easy to overwater. Some wilting before watering of larger size transplant quality, and in instances where some hardening of tender plants is desired prior to field setting, this is commonly practiced. In addition to reducing the amount of water applied, plants may also be hardened by subjecting them to higher light intensity and lower night time temperatures. Plants may be moved to cold frames or set outside on wagons to accomplish this. Hardening of any vine crop plants is not recommended.

During the growing season the grower should make daily entries in a permanent record book regarding that day's activities. At the end of the growing season a summary of activities should be prepared. These will be extremely valuable in planning for the next year.

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EFFECTS OF CROP ROTATION AND PLACEMENT ON DISEASES OF HORTICULTURAL LEGUMES

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ABSTRACT

Field plots have been established to determine the effect of a one-year rotation with an immune crop on survival of the propagules of the lima bean anthracnose and downy mildew pathogens. Corn, beet, squash, or tomato borders were planted around snap bean plots. The beans with borders were compared with nonbordered snap beans to test the effectiveness of borders as protective barriers against aphid transmission of nonpersistent viruses. The enzyme-linked immunosorbent assay method was used to identify certain common snap bean viruses. Locations were marked and counts made of the number of virus infected plants. The most common virus was peanut stunt, followed by clover yellow vein and bean yellow mosaic. Under the conditions prevailing and the low incidence of virus infections occurring in 1980 and 1981, none of the borders affected virus occurrence. A significant number of unidentified viruses occurred in the plots, the identity of which is being studied.

Keywords: Border plantings, lima bean anthracnose and downy mildew, rotation, small farms, snap bean viruses.

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Snap beans (*Phaseolus vulgaris* L.) and lima beans (*Phaseolus lunatus* L.) are susceptible to well over fifty diseases caused by pathogenic fungi, bacteria, nematodes, and viruses (12). Several of these diseases can cause sufficient loss of yield or quality to be of economic importance.

Effective procedures for controlling plant diseases are basically methods of preventing disease occurrence. Unlike many human and animal diseases, most plant diseases are not curable. Most diseases occur sporadically and their severity varies from year to year, from area to area, and even from field to field. Growers, therefore, particularly those just starting production, need to be aware before planting of the diseases most likely to occur in their area and to be knowledgeable of effective methods for preventing infection or reducing disease severity.

The use of resistant varieties is certainly the most economical method of controlling plant diseases. Unfortunately, varieties of snap beans and lima beans resistant to all of their major diseases are not available. The use of pathogen-free seed, seed treatments, and applications of pesticides, crop rotation and other cultural practices are effective for preventing the occurrence or reducing the severity of many diseases.

Crop rotation is a procedure that is widely recommended for controlling certain diseases that are incited by soil-borne pathogens. It usually does not result in complete control unless extremely long rotations with immune crops are used, the pathogen involved has a very restricted host range, and the fields involved are isolated and in an area where the environment does not favor subsistence of the pathogen. Short rotations with nonsusceptible or immune crops, however, may be of value even though they may not give complete disease control. The reduction of pathogen propagules given by such rotations may be significant when coupled with the use of field-resistant or disease-tolerant varieties.

None of the disease-control procedures mentioned will control several of the virus diseases of snap beans and lima beans that are transmitted by insects. Several important snap bean viruses have long been known (12) to be transmitted by aphids from weed hosts into the crop. Due to the quick, nonpersistent, stylet-borne nature of the transmission of these viruses, insecticides usually fail to control virus introduction (2,13).

This paper concerns current research on control of lima bean stem anthracnose and downy mildew by the use of disease-resistant cultivars rotated with an immune crop, and control of virus diseases of snap beans by crop placement.

LIMA BEAN STEM ANTHRACNOSE AND DOWNY MILDEW

Stem anthracnose, caused by *Colletotrichum dematium* (Pers. ex Fr.) Grove var. *truncata* (Schuv.) v. Arx, is a major disease of lima bean in the southeastern United States (4). It has been reported as far north as Pennsylvania. This disease is frequently serious in home gardens and in commercial plantings.

The causal organism has a fairly wide host range (4). It is pathogenic to snap beans, soybeans, several other legumes, and it is believed to cause a fruit rot of eggplant and tomato. The pathogen is known to be capable of surviving the winter on lima bean refuse, and it is presumed to be able to do so on other susceptible plant tissues.

Lima bean cultivars that are resistant to anthracnose have been developed at the Beltsville Agricultural Research Center. These cultivars have performed well, compared to highly susceptible varieties, when exposed to epiphytotics of stem anthracnose.

Downy mildew, caused by *Phytophthora phaseoli* Thaxt., is a major disease of lima bean in the northeastern United States. It has rarely been reported farther south than North Carolina. The destructiveness of this disease has been a primary factor in shifting lima bean production areas from state to state during the past ninety years. The pathogen has a limited host range, possibly being restricted to lima bean. It appears unlikely therefore, that this fungus can live over winter on refuse other than lima bean (5).

Lima bean cultivars resistant to the four known pathogenic races of *P. phaseoli* (11) have been developed at Beltsville. Since the causal fungus in the past has been capable of producing new pathogenic races, it remains important to keep inoculum of the pathogen at as low level as possible.

Field plots have been established at Beltsville, Maryland to determine if propagules of the anthracnose and downy mildew pathogens present on lima bean refuge will survive a one-year rotation with a nonsusceptible crop such as corn, and if such propagules will survive a one-year rotation with a resistant lima bean cultivar.

SNAP BEAN VIRUSES

Introduction

Snap beans are susceptible to many virus diseases. At one time bean common mosaic virus (BCMV) was a major problem, but it is now largely controlled in the United States through use of resistant varieties (12). The major virus problems in the mid-Atlantic states at present are caused by bean yellow mosaic virus (BYMV), peanut stunt virus (PSV), and perhaps clover yellow vein virus (CYVV) (1,6,7,8). All three viruses are found in home garden and small farm plantings, sometimes at levels causing severe losses. All three are transmitted into beans by aphids in a nonpersistent manner from clover and other weed hosts, in which they overwinter. The aphids quickly acquire these viruses when feeding on an infected plant, but once acquired they remain infectious for only a few minutes to an hour. As a result, transmission usually occurs only to the first subsequent plant on which the aphid feeds. Seed transmission is not significant for PSV and does not occur with BYMV or CYVV. Resistant varieties are not available for BYMV and are very limited in number and quality for PSV (7,12). Little is known about resistance to CYVV in snap beans.

Fields of crops that become infected with viruses carried by insects from the surrounding area often show a gradient in the percent of infected plants from a high level on the outer edges to a lower incidence in the center (2,13). Alternative, nonhost barrier crops planted around the outer edges of certain crops have been shown to reduce the spread of viruses into these crops (2,9,10,13). Spread of nonpersistent potato virus Y by the green peach and other aphids from along the edges of fields containing infected nightshade into healthy green peppers was significantly reduced by a single barrier row of sunflowers (9), and more effectively reduced by a 15.2m (50 ft.) swath of beans outside the sunflowers (10). To our knowledge, use of such barriers or borders has not been tested as a method for reducing the incidence of bean viruses.

MATERIALS AND METHODS

During the 1980 and 1981 growing seasons we tested several kinds of borders for their effect on occurrence of aphid transmitted viruses in snap beans. Previous reports indicated that the green peach aphid, Myzus persicae (Sulzer), the potato aphid, Macrosiphum euphorbiae (Thos.), the cowpea aphid, Aphid craccivora Koch, the bean aphid, Aphis fabae Scopoli, the spirea aphid, Aphis citricola van der Goot, and the pea aphid, Acyrthosiphon pisum (Harris) are the principal vectors of the pertinent viruses (1,6,8). Records of each of these aphid species in the U.S. National Collection of Insects at Beltsville were examined to determine from which crops they were commonly collected. Sweet corn was found to be a host of all of them. Since it is not susceptible to any of the bean viruses, sweet corn cv. Silver Queen was used for both the 1980 and 1981 studies. In 1981, additional crops tested were tomato cv. Supersonic, squash cvs. Golden Summer Crookneck and White Bush Pattypan in mixed planting, and beet cv. Detroit Dark Red Medium Top, all of which are hosts of M. persicae and at least two of the other five aphids. The only susceptibility in any of these crops to the pertinent bean viruses is of tomato to PSV (1,6,8).

Separate, but proximal, plots were used in 1980 and 1981 that contained Codorus silt loam soil. Snap beans had been in the plots the previous summer, followed by a barley green manure crop that was plowed down 6 weeks before planting. Both plots were bordered on the outer edges by mowed weeds, including white clover. Additional white clover was seeded in March 1981. Fertilizer, consisting of 450 kg/ha of NPK (10-10-10) was applied one month before seeding the plots. Snap bean cv. Eagle, resistant to bean common mosaic virus but susceptible to the other viruses, was drill planted to give a 3-5 cm spacing between plants. In both years the treatments were randomized in each of three replicates. In 1980 the three treatments tested were corn borders planted on May 12, corn borders planted on June 3, and beans to the edge of the field. All beans were planted on June 3.

In 1981, five treatments were tested including borders of corn or beets planted May 6, squash planted May 18, tomato transplanted May 26, and beans to the edge of the field. In 1981 all beans were planted on May 26. Plant spacing for all border crops was on the narrow end of the acceptable range. In both years the first 4.6m (15 ft.) of each row, starting at the edge of the field, contained the appropriate border crop and the next 12.2m (40 ft.) of the central five rows in 1980, three rows in 1981, contained beans. The last 3m (10 ft.) again contained the appropriate border crop. In addition, in 1980 two rows and in 1981 one row, on either side of the central five or three rows, respectively, were planted with the appropriate border crop. Rows were spaced 1m apart. A preemergence herbicide, Dual 2E, was applied to the entire plot in 1980. This same herbicide was used in 1981 for the corn and beans, preemergence pyramin-TCA was used for the beets, preemergence cynalon and dinitro for the squash, but no herbicide was used on the tomatoes. The beans were sprayed every 7-10 days with Sevin and Methoxychlor to control bean beetles and leaf hoppers.

On September 2 and 3, 1980 and on July 14 and 15, 1981, every plant in the central row of beans was examined in the field for presence of virus symptoms. In 1981 this was also done for the next row south of the center row. The location and kind of symptoms were recorded for each apparently infected plant. Two or three affected leaves were harvested from each of the recorded plants. The enzyme-linked immunosorbent assay (ELISA) method (3) was used to detect presence of PSV, BYMV, CYVV, and alfalfa mosaic virus (AMV). Appropriate antisera in 1980 and conjugate in 1981 were obtained from Dr. O. W. Barnett, Clemson University. In 1981 a second indexing, harvest, and ELISA test was conducted on August 18 and 19. For this second ELISA test, 10 random plants, with or without symptoms, were sampled from the central row at 1m intervals.

In 1981, leaves from plants having moderate or severe virus symptoms, but that gave negative ELISA results for the viruses tested, were ground and used to inoculate greenhouse plants of a set of diagnostic differential hosts useful in identifying a large number of bean viruses. This portion of the work is still underway.

In 1981, yellow, water containing, aphid-trapping buckets were placed along the edge of the field for one day every two weeks. The trapped aphids were stored in formaldehyde and later identified to genus and species with assistance from Dr. Manya Stoetzel, taxonomist and curator of aphids for the U.S. National Collection of Insects at Beltsville.

RESULTS AND DISCUSSION

The number of virus-infected bean plants was very low in both 1980 and 1981 (Table 1). According to Dr. J. P. Meiners, (personal communication), who had used these same plots for snap bean research prior to 1980, a higher percentage of virus infected plants occurred in previous years. The lower incidence in 1980 may have been due to the unusual heat of that summer. The low incidence in 1980 may, in turn, have caused a low incidence in 1981, time being needed to recover from the shock of the highly unusual weather of 1980.

The results (Table 1) indicated no significant effect from any of the border treatments in either 1980 or 1981. The most frequently detected virus was PSV followed by CYVV and BYMV. No AMV was detected. The rather large proportion of plants with virus symptoms that contained none of these four viruses caused us to attempt to determine the identity of the pathogen in these plants in 1981. To date nearly all of the unknowns have proven to be mechanically transmissable to greenhouse bean plants, strongly suggesting the involvement of some virus. Reactions of test plants suggest several different viruses. The ELISA results from the second 1981 sampling identified a few additional virus infected plants. These are included in Table 1, but not in Figure 1. None of the symptomless plants from either the single harvest in 1980 or the first or second harvest of 1981 contained any of the viruses for which the ELISA method was used for detection. No symptoms were recovered from symptomless field plants on mechanically inoculated greenhouse plants.

In 1980, a higher number of virus-infected bean plants than would be expected in a completely random distribution occurred in the first meter of each row of beans closest to the edge of the field. In the plots having corn between the edge of the field and the beans, this was true of the beans just inside of the corn. In the unbordered plots, it occurred in the beans at the edge of the field. However, in 1981 no such pattern was noticeable (fig. 1.). The largest number of positively identified (ELISA) virus infected bean plants occurred in the second, middle replicate of tomatoes, but only one was present in the third tomato replicate. The occurrence of the increased number of infected plants at the end of the rows in 1980 suggested that a 4.6 m (15 ft.) planting of some aphid attracting crop, might reduce

Table 1. - Numbers of virus infected bean plants in plots bordered by various other crops.

	Virus and no. of infected plants[1]					
					Totals	
Year and Border	PSV	CYVV	BYMV	Unknown	Infections	Plants
1980						
Corn early	6	5	1	9	21	19
Corn	8	7	3	6	24	20
None	10	5	3	9	27	23
1981						
Beets	8	3	0	8	19	19
Corn early	11	3	2	5	21	21
Squash	12	1	0	4	17	17
Tomato	13	2	2	4	21	20
None (beans)	9	2	1	10	22	21

[1] Viruses identified serologically included PSV = Peanut Stunt Virus, CYVV = Clover Yellow Vein Virus, and BYMV = Bean Yellow Mosaic Virus. Due to the presence of more than one virus in some plants, the number of infected plants is sometimes less than the number of infections. The differences amoung various borders are not significant.

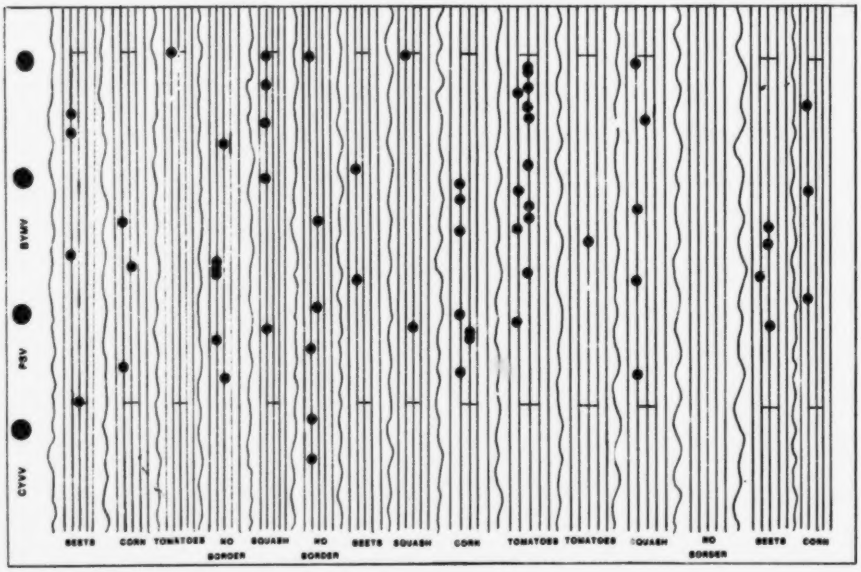

Figure 1. Diagram of 1981 field plot for testing effects of various border crops upon occurrence of aphid transmitted viruses in beans. The locations of ELISA identified virus infected plants are shown in the left two of the three central bean rows in each plot.

virus incidence farther into the field. Corn did not serve that purpose. However, the 1981 results suggest that a much wider border area would be needed for such a possibility. The 1981 distribution of virus infected beans appears to be completely random throughout the plot.

The results of both years are strong evidence that winged aphids can easily transmit bean viruses for a distance of at least 16.8 m (55 ft.). It seems logical to assume that under favorable conditions for high rates of aphid transmission, beans should not be planted any closer than 17 m and probably considerably more distant from the source of the virus. However, more data, obtained in a year in which virus incidence is high, is needed before making firm conclusions.

In a year when virus infection occurs at a high frequency, it is possible that results from experiments such as we conducted could be positive. Only a few of the many possible border crops have been tested, although we have tested some of the apparently most likely candidates, based on the host ranges of the aphids and usefulness of the crops. If many other alternative crops were tested, one or more might be found that would work. More research is also needed to compare various widths of border plantings before it can be concluded that such plantings would have no value in reducing incidence of virus infection.

Nearly half of all the aphids trapped in 1981 were M. persicae. The remainder were scattered among 10 more or less related species, with one or a few in each species. This suggests that M. persicae is the primary aphid involved. Based upon earlier work (9,10), use of an insecticide to control this and related aphids on the weeds surrounding bean fields may reduce virus incidence. Such a practice has not been tested for controlling bean viruses.

These results also strongly indicate the need for development of virus resistant cultivars for use by home gardeners and small farmers.

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NEW METHODS FOR FRUIT PRODUCTION ON SMALL FARMS

Miklos Faust[1]

ABSTRACT

Family fruit farms are usually located close to population centers and market their fruit either through roadside market or pick-your-own operations. They have developed, or are in the process of developing, unique planting systems. These plantings enable the grower or the public to harvest the fruit in a relatively advanced tree-ripe condition. Among these systems, the high density orchards and the uniquely planted, and renovated strawberry production systems are mentioned in detail. The small family fruit grower in general uses very sophisticated growing techniques which are not highly mechanized. Family fruit growers have specialized needs for research. In fruit production the small grower is the one who leads the way in sophistication of planting systems and understanding the physiology of the plant so that he can utilize this knowledge for his own profit.

Keywords: Small farms, roadside markets, pick-your-own operations, fruit, berries, production systems, dwarf trees.

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INTRODUCTION

Family fruit farms are distinguished from large production orchards by their size and location. Such farms operate on relatively small acreage and they may or may not be located close to population centers. Family farms located in major fruit growing areas are often part of cooperatives and their operation is not greatly different from the large production orchards. These orchards mostly grow only one type of fruit and market the fruit commercially through their cooperative. In contrast, those family farms which are located near the cities often grow several types of fruit and market their product through roadside markets or pick-your-own operations. These latter type orchards require specific methodology. Because of necessity, roadside markets or pick-your-own farms often specialize in producing and selling either berries or tree fruits; occasionally both are grown. All family farmers operating near the population centers desire to serve their customers by supplying them with a wide range of fruit which they produce themselves. The special needs and concerns of family fruit growers will be briefly discussed.

HIGH DENSITY ORCHARDS

To utilize the land best, orchards need to be high density with relatively small trees. Dwarf trees have many advantages for the grower. They are easy to harvest from the ground; the center of the tree is not shaded resulting in better fruit quality; spraying can be well adjusted to the tree, saving spray material and decreasing pollution; and the trees utilize the land well. The major disadvantage of such orchards is that only apples and pears are readily available as dwarf trees; peaches, plums, apricots, and cherries are difficult to dwarf. Even with apples the trees are expensive and the high number of trees needed per acre (Table 1) make it almost impossible to plant them economically.

In addition to the greater number of plants required, dwarf orchards usually require a trellis or poles for support since the dwarfing rootstocks generally have weak root systems. Since the root system of the present dwarf trees is small, irrigation is often needed which may not be the requirement for larger rooted large trees.

In calculating the investment needed for a dwarf apple orchard and in comparison to that required for a standard orchard, the following estimation can be made (Table 2).

It is clear that dwarf orchards are expensive costing often 2-to-3 times the value of the land. There are two possible avenues to reduce this cost: (1) To develop trees less expensive to establish in high density plantings, and (2) to plant trees at low density but handle the trees as though they were high density tree walls.

Present dwarf trees are apples grafted on M.9 or similar rootstock, pears on quince, and cherries and peaches on Prunus tomentosa which does not produce a good tree. Research is going on to develop genetic dwarfs of apples, pears, plums, peaches and nectarines. Dwarfing of these trees would reside in the tree itself and would not need the dwarfing of the rootstock. In a separate line of research we are learning to propagate such trees on their own roots which should produce relatively inexpensive ungrafted trees. Self-rooted dwarf trees, as far as we can tell today, will not require a trellis and their water need is not different from the large trees. Thus irrigation on the account of dwarfness is not needed. When the two lines of research, the dwarf tree development and the propagation methods, are both completed, high density orchards using inexpensive dwarf trees will become a reality.

An alternative system has been developed in Italy. This system has been developed to fit a variety of tree species, some of which cannot be dwarfed. The most important feature of this system is that it elevates the workers to the tree; thus there is no need to bring the tree "down" to the workers by dwarfing it. This production system is called the Italian palmette and it is uniquely suited to the needs of family farmers. The Italian palmette received its name from the fact that the trees are flattened in a fashion that resembles the leaves of palm trees. In the past this system necessitated a trellis on which the trees were trained. The present informal palmette is an improvement and does not require wires and poles. The palmette trees are generally relatively high trees and most of the work is done by hand with the aid of power tools attached to the self-propelled platform. This is the only piece of equipment the grower needs. Workers standing on the platform prune with pneumatic pruners, thin fruits (stone fruits) with pneumatic shakers, and harvest fruit at a stage of ripeness that the fruit is salable immediately at the roadside market. A sprayer can be attached to the platform if necessary.

Most of the effort in North America, so far, has been directed toward achieving complete mechanization. This includes the effort to mechanize harvesting. Large monocultures can be mechanized by building special machines for the particular purpose. Fruit is usually harvested firm and shipped to the market when it ripens. This system, although producing a relatively inexpensive product, produces fruit of a lower quality. The strength in roadside marketing is that the fruit is not shipped long distances and can be harvested in a relatively "tree-ripe" condition. Machine harvesting such fruit is not possible. Thus we have to consider the mechanical-aid-assisted hand harvest. This is a departure from our previous thinking. The platform used in tree-wall-type orchards developed as Italian palmettes would be a mechanical aid which is adapted to family fruit growers.

To complete the picture of a family fruit grower operation we need to discuss the protection of

Table 1. Tree requirement per acre at various planting distances.

Tree spacing (ft.)	Trees per acre	Type of Tree
30 x 30	48	Large apple trees grown in the past.
18 x 24	101	
14 x 20	156	Semidwarf apples, peaches, plums
12 x 18	201	
10 x 16	272	
8 x 16	340	
6 x 14	519	
6 x 10	700	Dwarf apples on M.9, pears on quince, peaches on *Prunus tomentosa*[1]

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[1] M9, a selected apple rootstock, quince and *P. tomentosa* are used for dwarfing rootstock.

Table 2. Investment needed per acre for high and low density apple orchards.

Components	High ($ per acre	Low ($ per acre
Orchard land	$3000-5000	$3000-5000
Trees	$3500 (700 trees @ $5)	$ 750 (150 trees @ $5)
Trellis	$2000	0
Irrigation	$2000	0
Maintenance until production	$1500 (3 years @ $500)	$2000 (5 years @ $400)
Total Investment excluding land	$9000	$2750
Ratio (Land cost:orchard cost)	1:3-1:2	1:1-1:05

trees from various pests. This is important for the future of orchards that are often wedged into housing developments where the spray drift is undesirable and the orchard is often visited by large numbers of people who should not be exposed to pesticide residues at levels normally existing in the orchards. It is clear that better methods are needed for orchard protection on family fruit farms. The integrated pest management practiced by most growers is an important step forward in decreasing residue levels. The development of ultra-low-volume sprayers, especially those with electrostatic heads, may further decrease the residue levels. The most important development, however, will come from the fact that sprays can be directed to the tree from close range regardless of whether the trees are dwarfs or arranged in tree-walls. In both cases the nozzles of the sprayers can be calibrated and adjusted to put out only the needed amount of pesticides. With present trees the bottom of the tree is quite often overloaded by the time the top receives the right amount of spray. With closely calibrated spray machines this waste will be eliminated.

We estimate that either of these new type orchards will use 1/3 to 1/4 the chemicals required by the present systems. Improved formulation of sprays could use heavier than water carrier liquids which would decrease or eliminate drift. We have indications from limited trials that the above systems can be developed.

PRODUCTION OF BERRIES - OR SO CALLED SMALL FRUITS

Virtually all strawberries east of the Rocky Mountains, with the exception of Florida, are now harvested in pick-your-own fashion. It is desirable to extend these operations to blueberries, blackberries, black and red raspberries, and, occasionally, grapes. Soil and/or climate at many locations is unsuitable for some of the above plants. Blueberries grow on mineral soils only with substantial mulch. Often mulch is not available or it is very expensive. Thus the areas in which blueberries can be grown are limited to the Atlantic coast and Michigan. Thornless blackberries are limited by winter temperatures to a triangle which extends from New Jersey to Carbondale, Illinois, to North Carolina. Virus infection is a problem with red raspberries in warmer climates; thus this plant is limited to the North.

Family farmers often operate on soils which have been in use for most of this century or longer. Such soils are frequently infected with a variety of soil-borne-disease organisms. Among these pathogens, species of Phytophthora and Verticillium are the most important. Fumigation of the soils is expensive and does not provide sufficient protection against the above diseases. Thus, plants must be resistant to these diseases. All this necessitates that cultivars adaptable to the prevailing conditions must be developed. These are completely new viewpoints developed because of the variety of needs for pick-your-own farms.

Strawberries are one of the most important berry crops grown by pick-your-own operators. The new methods introduced into strawberry production have changed the production technique. The new large-fruited cultivars with a relatively strong skin have made a difference. The tougher skin allows growers to let people pick when 50% of the berries are fully ripe. Naturally such berries develop better flavor. We proudly note that the Beltsville introductions 'Redchief', 'Guardian' and 'Earliglow' are the leading cultivars, with others such as 'Apollo', 'Titan', 'Rosanne', 'Prelude' and 'Sumner' coming from our cooperative programs. These cultivars maintain a yield advantage regardless of the production system.

Presently, growers plant more plants per acre and keep the beds narrower, thus reducing plant-to-plant competition and increasing yield. The soil is prepared more thoroughly before planting, resulting in faster establishment of the root systems. Permanent irrigation has been installed on many strawberry fields, and pesticides and fertilizers are supplied through the irrigation system to maintain optimal conditions.

Growers have learned to renovate the beds by mowing the fields soon after harvest, spraying them with insecticide-fungicide combinations, and rototilling the rows, throwing some soil on the crowns. The crowns develop new roots above the existing roots which invigorates the plants. Strawberry beds can be kept productive this way for 3 to 4 years, thus reducing the cost of replanting.

New methods of production such as the ribbon-row culture have also been developed. In this system growers set plants 3 inches apart in the row during the summer from cold storage. Instead of removing the blossoms they allow them to fruit; thus they recover the planting cost 60 days after planting. The next spring, the plants produce about two-thirds of normal yield which is sufficient to give a reasonable profit. The planting then continues with the renovation techniques described above.

SUMMARY

It is impossible to describe all the methods applied by small family farmers for fruit production. I am only presenting a few examples which show the high level of sophistication needed by farmers to realize a profit. For all practical purposes, we can say that the small family fruit grower is the leader in new production technology. This does not necessarily mean that he is the leader in mechanization. In fact, he adjusts his production system to limited use of machinery. By using very sophisticated technology, he can maintain profits without resorting to much expensive machinery. His success depends on timeliness of application of the techniques, use of the best plant material available, and the development of technology uniquely suitable to his special conditions.

The family fruit grower also deals with the public either through his roadside market or through the pick-your-own system. This puts him in a unique position to evaluate immediately consumer reaction to his product or to the production system. He has definite research needs. In fruit production, in many respects, we expect large production systems to adapt methods pioneered by the small farms instead of vice-versa, which is the case with many of the other commodities. Hopefully, this brief presentation will help focus the attention of researchers to these needs.

THE HORNFACED BEE FOR EFFICIENT POLLINATION OF SMALL FARM ORCHARDS

S. W. T. Batra [1]

ABSTRACT

Osmia cornifrons is a highly efficient pollinator of rosaceous tree fruits (*Pyrus* and *Prunus* spp.). It is managed commercially in Japanese orchards, and it has been introduced into the eastern United States. Due to its effectiveness, docility, ease of handling and short flight range, it is well adapted for use on small farms.

Keywords: Apple, bee, direct marketing, fruits, honey bee, insecticides, Japan, orchards, *Osmia* peach, pollination, pome, *Prunus*, *Pyrus*, small farms, stone fruits.

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The rosaceous tree fruits, apple, pear (Pyrus spp.), peach, plum, apricot, nectarine and cherry (Prunus spp.) require or benefit from insect visitation for cross- or self-pollination and adequate fruit yields (3, 6).

Due largely to cultural practices and heavy insecticide usage in modern orchards, populations of native pollinators are often inadequate, especially in Europe, North America, and Japan (2, 3, 5). Although honey bees are usually recommended, and hives are commonly placed in orchards for pollination (6), these insects are not fully satisfactory, especially on small farms, for several reasons:

1) Honey bees have a large foraging range (to 3 km) and are apt to leave the vicinity of the hives and orchard.

2) Honey bees are often readily attracted to flowering weeds or plants other than the fruit trees.

3) Honey bee rental for pollination costs (e.g., $14-15 per hive for 7-10 days' use in 1981 on apples in Virginia, according to P. Powers, State Apiculturist).

4) Rental colonies are difficult for small orchardists to obtain.

5) If not rented, colonies must be maintained, fed and protected from pesticides and parasites all year (this may be offset if enough honey and wax are produced).

6) Honey bees sting readily and painfully, therefore colonies are often not welcome in backyard or small farm orchards having much human or animal activity. This may become more significant if breeding with "Africanized" honey bees (Apis mellifera adansonii hybrids) occurs in North America.

Management in Japan

The hornfaced bee, Osmia cornifrons (Radoszkowski), has been commercially employed for fruit pollination in Japan for several decades (7), despite the availability of honey bees and (formerly) relatively cheap labor for hand pollination. The docility and effectiveness this solitary megachilid bee was first noticed by a small farmer, Mr. Eikyu Matsuyama, of Tsurutamachi Village near Hirosaki. In the 1930's he independently devised methods for attracting the bees and maintaining populations in his apple orchard. His technique was spontaneously adopted by neighboring farmers, and subsequently improved by agricultural research. The use of O. cornifrons in Japan has now reached most fruit-growing prefectures (in Hokkaido, Aomori, Akita and Awate, on apples; in Yamagata and Fukujima on apples and cherries; in Nagano on pears and apples, and in Yamaki perfecture on peaches, cherries and plums); the area of use continues to expand (5).

In Aomori prefecture (25,000 ha in apples), about 70 percent of pollination is still traditionally done by hand (fig. 1), despite high cost (30 person-days/ha needed at $800/ha for pollination). The acute shortage of wild pollinators and labor during the two-week bloom period often results in the recruitment of military troops for hand pollination. Hives of honey bees (rental fees $5-40 per colony) are placed in 20 percent, and 10 percent of all orchards are pollinated exclusively by O. cornifrons. The most progressive growers, who use hornfaced bees, are willing to modify cultural practices and to cooperate with neighbors in order to achieve most effective use of these insects. Entire valleys or villages may rely only on these bees for fruit pollination, for example, village Nagauma near Nagano, 350 ha supporting 500 families; Okozawa Village near Hirosaki, 80 ha supporting 80 families.

Orchards of progressive Japanese growers may yield 80 T/ha; the average yield is 20-30 T/ha. The small orchards (average size about 1 hectare or 2.5 acres) are intensively managed, and each can support a family at a comfortable standard of life, including modern conveniences. For example, one progressive farmer's 1.4 ha orchard of "Fuji" apples near Nagano supports a family of 7 (no off-farm income). He also hires 150 harvesters at $20/day each. He nets about $50,000 from the sale of fruit. About 10,000 hornfaced bees are kept as the sole pollinators of his orchard.

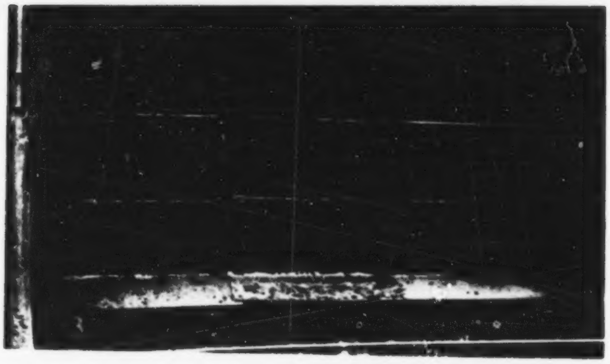
Japanese growers get a good price for their fruit, especially if they are near urban areas. Fruit may be sold through wholesalers, however, higher returns and assured markets are obtained when the grower works on contract for a group of urban consumers (some have had the same customers for 30 years). Pick-your-own operations are also popular; for example, 90 percent of apples at an orchard near Sapporo were harvested by customers and only 10 percent went to market. Apples are grown on about 50,000 ha in Japan, yielding 1 million tons.

The management of O. cornifrons in Japan is precise. Bees are provided with nesting materials (usually cut, hollow Phragmites reed sections, but occasionally commercial cardboard tubes or "B-tels"). These are bundled and kept under the eaves of buildings or in specially constructed bee shelters in the orchard (figs. 2, 3). The natural emergence of adults of this univoltine bee coincides with the bloom of peach (4), cherry and plum. It is necessary to delay the emergence and activity period of the bees for pollination of the later-blooming apples (5). In order to delay emergence, the bees' nests (reeds filled with cells) are removed from the orchards in late winter and stored at about 5°C (usually in the apple storage cooler). The nests are replaced in the orchard 7-10 days before apple bloom is expected to begin (the flowering of cherries is used as an indicator). The bees emerge within a few days, mate, and are ready to begin pollination and nesting just as apple bloom begins. The abundance of apple flowers permits rapid reproduction and an eightfold annual increase in bee population may occur under timed-release management (unmanaged populations may double annually). Excess bees are sold (at $0.10 each).

Parasites (particularly Chaetodactylus sp. mites) are controlled by sanitation; the bees are encouraged by selective placement of nesting materials to accept new nest reeds annually and abandon the old ones, which are burned. Bees are protected from insecticides by the elimination of two applications from the usual heavy spray schedule. No pest increase occurs. The last insecticide is applied 2 weeks before buds break for leafroller control. The first insecticide application after bees emerge is applied after all petals fall, which kills adult bees remaining in the orchard. However, most reproduction has been accomplished and the brood is protected by the impervious reeds and cells. Some adult mortality occurs when broadleaf herbicides applied to neighboring rice fields are ingested by females gathering

Fig. 1. Hand pollination is traditional in Japan. Pollen is applied with a brush (arrow). Many wild pollinators have been eliminated by insecticides and intensive cultivation.

BEST DOCUMENT AVAILABLE



Figs. 2, 3. Hornfaced bees nest in reed sections kept in shelters placed in the orchards. Each reed contains the nest of one female bee, consisting of about seven cells. About 7,000 bees per hectare are required for adequate pollination.

mud for brood cell construction. Nets over shelters prevent raids by predatory birds.

Hornfaced bees are more efficient pollinators of apples than honey bees, due to their preference for apple bloom, short flight range (about 100 m), rapid flower visitation rate, and consistent anther contact. The two pollinators were compared at an orchard in full bloom near Hirosaki, at noon on a sunny day. Three trained observers each independently watched a 9 sq m area of apple bloom (in different trees) for 15 minutes, and data were pooled. Selected branches were equidistant (50 m) from an apiary of 29 hives with supers (1,160,000 honey bees) and a shelter with 20,000 nesting O. cornifrons. Honey bees visited flowers at an average rate of 8.5/minute; hornfaced bees averaged 15 flowers/minute. More significantly, honey bees pollinated (actually contacted anthers and stigmas) of only 4 flowers, but hornfaced bees pollinated 105 flowers during the same period (71 ♀ collecting pollen, 20 ♀ collecting nectar, and 14 ♂ pollinated). Evidently numerous honey bees were foraging outside the orchard that had hired their services. Several Japanese scientists informed me that this behavior pattern is normal.

Trials in the United States

Osmia cornifrons was first established in the United States at Beltsville, MD, in 1978 (1). Since then, the population has doubled annually, and bees have been redistributed to scientific collaborators elsewhere in Maryland for trials on apples and peaches (1978-81); at Rutgers, New Jersey (1980), and at Ithaca, New York (1980) for apples; at Raleigh, North Carolina (1980-81) for apples and peaches; and in the District of Columbia (1980) for use on urban fruit trees. Reproduction and survival was good in all areas except the central Adirondack Mountains (N.Y.), where the winter temperature reached -40° C.

Native Phragmites reeds were the most satisfactory nesting material (average of 7 cells/reed produced); native Monodontomerus sp. wasps were able to penetrate nests in paper soda straws, destroying many bee larvae so that reproduction (1.1 bee/straw) was below population replacement level. Plastic soda straws were subject to fungus infestation. It was possible to eliminate Monodontomerus by using reeds, and also by storing cell-filled reeds during the summer in insect cages kept in a dry, shady place. Monodontomerus wasps emerging from nests during summer were attracted to light and died inside the cages. Parasitism was thus reduced to below one percent by the 1980 season. Some predation by mockingbirds (Mimus polyglottos) could be prevented by covering bee shelters with nets; however, these birds ate many mating bees that had settled on plants.

At Beltsville, the first male bees emerged about a week before (3/23-4/1) the first females (4/1-4/7). Nesting and pollen collection by mated females (4/7-4/10) began about three days after first females appeared. This coincided with the beginning of bloom of apricots, cherries, plums, almonds, pears and early peaches during four seasons (1977-1980). Apple bloom began about 10 days after nesting activity started, thus resembling conditions in Japan. Therefore, the most effective utilization of this insect on apples would require timed release management.

A multiple-choice test, in which cut branches of flowering fruit trees were placed near a bee shelter indicated the following selection (based on number of bee visits per minute) in declining order of preference: crabapple; Royalvee peach; Early Redhaven peach; Loring 51-24 early peach; early apricot No. 8; B-69 plum; Delicious apple; Tex PT-21 plum; Faroria peach; Bartlett pear; U.S. No. 220 pear. Bees did not visit pear No. 278; Magness pear (pollenless); and native *Amelanchier canadensis* (highly attractive to native *Andrena* and other solitary bees).

Osmia cornifrons can be successfully used for fruit pollination in the United States. Major obstacles still to be overcome are:

1) Obtaining or rearing sufficient bees for redistribution. Imported bees must be individually inspected to detect parasites. A colony may be started with about 200 bees; however, about 7,000 bees per hectare are needed for pollination.

2) Finding an inexpensive commercially available substitute for *Phragmites* reeds, necessary if the bees are to be widely used.

3) Educating growers to slightly modify their spray schedules.

4) Increasing public awareness of the economic potential of certain solitary bees that are "tailor-made" for use on specific crops.

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STORAGE AND MARKETING OF SEVERAL TABLE GRAPE CULTIVARS INDIGENOUS TO THE NORTHEASTERN UNITED STATES

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ABSTRACT

Storage and marketing studies with several table grape cultivars (cv) indigenous to the Northeastern United States and Canada were initiated to determine the storage life of those cv and their acceptance to the consumer at several roadside markets. All cv stored well up to 30 days and the use of one SO_2 packet per 9 kg of fruit doubled the storage life of those cv. Differences in quality were noted among cv and storage treatments. Production problems also were evident for the cv Himrod, Lakemont and Suffolk Red. Results of the initial marketing study suggest there is a good potential for capturing about one-third of the present Thompson seedless Market. This percentage could increase as consumers become aware of, and more familiar with, the local table grapes.

Keywords: Viticulture and fruit enterprises, agriculture, economics, extension, farmers, Northeastern region, research, small-scale farms, survey, technology.

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INTRODUCTION

Several table grape cv developed in Canada and the Northeastern United States seem to have commercial potential from the production viewpoint (2,11,12). Some of these cultivars were introduced recently and others have been available for several years, but have had production problems. There are recent data which indicate some alleviation of the production problems related to the earlier introductions (4,11,13). Recent changes in energy priority, costs of shipping grapes from the West Coast and the large number of farmers and roadside markets in the northeast provide a marketing environment considerably more conducive to producing table grapes on small farms than has been evident for many years. With respect to storage, it appears that storage in non-vented containers and the use of sulfur dioxide (SO_2) may hold some promise for storing these newer eastern introductions for one to two months (1,3,5,6,10,11). Storage temperatures appeared to be optimum in the range of 0 to 2C (3,4,6,8) and there was some indication that a 12-inch storage pack may be preferable (8,9). However, sound, factual information on storing, handling and marketing of these cultivars is lacking. Therefore, research is necessary in these areas before the small farmer can be encouraged to produce, store and market some of the promising table grape cultivars indigenous to the northeast. Grape production also offers an opportunity for low income families on small farms to enhance their income and improve their standard of living. However, these small farm operations often find it difficult to market their production through commercial or conventional channels because of their low volume. The most viable alternative to this situation appears to be that of marketing through farmers' and roadside markets. The objectives of this research project were to conduct storage and direct marketing studies with one or two promising Northeastern table grape cultivars at farmers' markets and roadside stands. Therefore, studies concerned with the storage, handling and marketing of several of these cultivars were initiated in the summer of 1980.

METHODS AND MATERIALS

Storage Study

The five cvs used in this trial were Lakemont, Himrod, Suffolk Red, Festivee and Canadice, all of which are seedless except for Festivee. Cultivars were stored up to 90 days at 1 to 2C with and without SO_2. Fruit of each cv was removed at 30 day intervals after commencement of storage except for Lakemont. Initial time of removal from storage for Lakemont was 7 days in order to coincide with the marketing study. Festivee and Canadice were not replicated as there was not enough material available for replication. However, they were held up to 90 days with and without SO_2. Sulfur dioxide packets were obtained from Quality Packaging, Inc. of Antioch, CA. The concentration of SO_2 emitted from these packets ranges from 4 to 10 parts per million. Fruit (9 kg/container) was packed in plastic bags which were sealed at the top with a wire twistem. Lakemont was the only cv that was marketed during the storage season.

Measurements taken in these tests included berry weight, soluble solids (SS) at harvest and at each time of removal from storage, titratable acidity (TA) at harvest and at each time of removal from storage as well as pH of the juice. Soluble solids and (SS/TA) ratios were also calculated for each CV at each time of removal from storage. Observations included the incidence of SO_2 injury, the condition of the cluster with respect to stems and fruit; and the occurrence of mold, rot, and loose berries. Shelf life was determined by leaving the clusters at 21C for a period of seven days after removal from storage. Treatments were arranged in a split plot design and were replicated three times. Means were separated by the use of Duncan's Multiple Range test (7).

Marketing Study

Three year-round representative stands were selected for the study; one each in Berks, Cumberland and Lancaster Counties. Only fruit of the cv Lakemont was utilized in this study. All three markets have regularly sold California Thompson seedless white grapes and have storage facilities. Since there was a limited supply of Lakemont grapes, farmers' markets could not be included in the study. The marketing study commenced on September 19th in each market with six boxes of treated and six boxes of untreated Lakemont fruit displayed beside fruit of Thompson seedless. Five boxes of each group also were marketed the weekend of October 24th and another five boxes in each group were marketed the weekend of November 21st. Grapes were kept in cold storage except when displayed for sale. Two signs, "PA Grown Lakemont Seedless" were displayed with each box of Lakemont and another sign, "California Thompson Seedless: was displayed with the California grapes. A box of Lakemont "treated" grapes was displayed on one side of the Thompson and a box of "untreated" was displayed on the other side. Initially, the Lakemonts were priced at the same level as the Thompson. If they did not move after two days, the price was dropped ten or twenty cents per pound below the Thompson seedless. Each market kept a record of the amounts sold and prices received each day of the study.

RESULTS

Cultivars

Berry weight and all quality measures exhibited significant differences among cv (Table 1). Suffolk Red berries were heavier than those of Himrod, whereas Lakemont berries were lighter than those of Himrod or Suffolk Red. Soluble solids percentage did not differ between Lakemont and Suffolk Red. However, both were significantly higher in soluble solids value than Himrod. Juice pH of those cv revealed the same pattern as soluble solids values. Himrod fruit was lower in pH than Lakemont or Suffolk Red whose values did not differ significantly.

Table 1. Berry weight and quality measures for three northeastern seedless table grape cultivars during the 1980 season.

Cultivar	Berry wt (g)	Soluble solids (%)	pH	Titratable acidity (g/100g)	Soluble solids / Titr. Acid
Himrod	1.82 b	16.2 b	3.24 b	1.07 a	15.0 b
Lakemont	1.43 c	19.5 a	3.42 a	0.81 ab	24.0 a
Suffolk Red	2.32 a	19.4 a	3.37 a	0.79 b	24.7 a

Table 2. Effect of storage duration on quality factors of three northeastern seedless table grape cultivars.

Length of storage (days)	Soluble solids (%)	pH	Titratable acidity (g/100g)	Soluble solids / Titr. Acid
0	18.9 a	3.42 a	0.90 ab	21.6 ab
30	18.5 ab	3.34 ab	0.95 a	20.0 b
60	18.1 ab	3.31 b	0.89 ab	21.0 ab
90	17.9 b	3.30 b	0.84 b	22.4 a

Table 3. Effect of sulfur dioxide packets on the quality factors of three northeastern seedless table grape cultivars during the 1980-81 storage season.

Treatment	Soluble solids (%)	pH	Titratable acidity (g/100g)	Soluble solids / Titr. Acid
SO_2 packet	18.4 a	3.36 a	0.88 b	21.5 a
No SO_2 packet	18.3 a	3.33 b	0.90 a	21.0 a

TA values were higher in Himrod fruit than in fruit of Suffolk Red. SS/TA ratios also differed significantly among cultivars, as Himrod was lower in this value than either Lakemont or Suffolk Red, which did not differ significantly in this respect.

Storage Duration

All measures of fruit quality were affected significantly (Table 2). Soluble solids decreased, but the reduction was significant only between fruit at harvest and that of fruit held in cold storage for 90 days. Titratable acidity was significantly lower after 90 days in cold storage than after 30 days in storage. Fruit pH values were significantly higher 60 and 90 days after harvest than at the time of harvest. Soluble solids-acid ratios followed the same pattern as titratable acidity in that after 90 days in cold storage this value was significantly greater than that of fruit held 30 days in cold storage.

Sulfur Dioxide

The use of SO_2 had little effect on quality measures (Table 3), as it did not alter soluble solids or the soluble solids-acid ratio. Although the difference appears small, pH value was lower in treated fruit than in non-treated fruit while the opposite trend was noted for titratable acidity. The affect on pH and titratable acidity may be due to formation of a weak solution of sulfuric acid upon release of SO_2 from the packet which decreased with time. Several interactions were evident, primarily between cultivars and duration of storage. Therefore, determination of the effects of SO_2 treatment and storage on SS, TA, pH and the SS/TA ratio by cultivar was essential. These data are presented in Tables 4 and 5.

Effects of Storage by Cultivar

Himrod

Percent soluble solids were significantly lower 30 days after storage than at harvest. However, it was not significantly lower after 90 days in cold storage than at the initial time of removal from storage (Table 4). Titratable acidity increased in the fruit after 30 days in storage, but returned to the value indicated at the time of harvest when the fruit was removed after 60 and 90 days in storage. Again, the increase within 30 days may have been due to the release of sulfur dioxide from the SO_2 packets.

Table 4. Quality measurements for three northeastern seedless table grape cultivars at harvest and during a 90-day storage period in 1980-81.

Cultivar	Length of storage (days)	Soluble solids (%)	pH	Titratable acidity (g/100g)	Soluble solids/Titr. Acid
Himrod	0	16.8 a	3.33 a	1.06 b	16.0 a
	30	16.0 b	3.22 c	1.13 a	14.2 a
	60	15.8 b	3.16 d	1.05 b	15.1 a
	90	15.7 b	3.27 b	1.05 b	15.0 a
Lakemont	0	19.8 a	3.52 a	0.82 a	24.2 a
	30	19.8 a	3.45 b	0.83 a	23.9 a
	60	19.6 a	3.44 b	0.85 a	23.1 a
	90	19.0 a	3.26 c	0.76 b	25.0 a
Suffolk Red	0	20.0 a	3.43 a	0.82 b	24.6 b
	30	19.5 ab	3.34 a	0.88 a	22.1 c
	60	18.9 c	3.31 a	0.76 c	25.0 b
	90	19.1 bc	3.38 a	0.70 d	27.2 a

Table 5. Effects of SO_2 packets on fruit quality of three northeastern table grape cultivars during the 1980-81 storage season.

Cultivar	Treatment	Soluble solids (%)	pH	Titratable acidity (g/100g)	Soluble solids/Titr. Acid
Himrod	SO_2	16.3 a	3.22 b	1.10 a	14.5 b
	No SO_2	15.9 a	3.26 a	1.05 b	15.6 a
Lakemont	SO_2	19.5 a	3.41 a	0.81 a	24.0 a
	No SO_2	19.6 a	3.42 a	0.82 a	24.1 a
Suffolk Red	SO_2	19.2 a	3.35 a	0.80 a	24.5 a
	No SO_2	19.5 a	3.38 a	0.78 a	25.0 a

Values for fruit pH decreased, corresponding to an increase in TA and tended to increase with the longer storage duration. The SS/TA ratio was not significantly affected by storage duration. SO_2 did not affect SS, but did alter pH, TA and the SS/TA ratio (Table 5).

Lakemont

Soluble solids and the SS/TA ratio were not altered by the length of time fruit was held in cold storage (Table 4). Fruit TA was lower at the 90 day time of removal than at harvest or at other dates of removal from storage. A significant decrease in pH value was noted after 30 days in cold storage with no change between 30 and 60 days, but a significant reduction in pH was observed between the 30 and 90 day storage interval. SO_2 did not affect fruit quality (Table 5).

Suffolk Red

Soluble solids of the fruit was erratic, although after 60 and 90 days this value was lower than at harvest (Table 4). TA patterns were similar to that of Himrod, as TA was significantly higher at the 30 day removal date than at harvest or at other dates of removal from storage. The SS/TA ratios also were erratic with the highest value observed after 90 days in cold storage. The change in that value, basically, reflected the trend for acidity. Again, SO_2 did not affect fruit quality (Table 5).

Other Cultivars

Observations were made for two other table grape cultivars - Canadice and Festivee. Canadice is an early, red, seedless cultivar; whereas, Festivee is a large blue non-slip skin, seeded grape. Both cvs produce well provided bird depredation is controlled (Table 6). Quality characteristics differed between these cv (Table 7). Soluble solids and TA values for Canadice tended to decrease after 30 days in storage. However, the soluble solids/acid ratios did not appear to change significantly. Values for SS had the same trend for Festivee as for Canadice, but TA values were variable for Festivee. Soluble solids-acid ratios and pH values decreased with the length of time Festivee fruit was held in storage. Those values for Canadice did not appear to change greatly during storage. Sulfur dioxide packets had little effect on the storage factors measured for these cvs (Table 8).

Evidence of mold and decay began to become significant in non-treated fruit between the 30 and 60 day storage interval. Festivee was the most resistant of the five cultivars to mold and decay followed in order by Suffolk Red, Lakemont, Canadice and Himrod. Mold and decay were not evident in treated fruit of any cv after 90 days in storage. Skin of Himrod fruit is very tender followed in order by Lakemont, Suffolk Red, Festivee and Canadice. Stems of Himrod and Lakemont also were easily broken, particularly if they were handled when cold. Festivee stems shrivelled and turned brown, but were not as easily broken as Himrod and Lakemont. Suffolk Red stems were intermediate in this respect and Canadice stems appeared to be the most resistant to breakage.

Marketing Study

The price of the California Thompson seedless grapes ranged from 59 cents to $1.19 per pound with an average price of 89 cents per pound during the period of study. Lakemont fruit were offered at similar prices as Thompson seedless but were discounted 20 cents per pound when necessary. The price of Lakemont went to a low of 35 cents per pound in the October marketing period for the untreated grapes because of their poor appearance and quality.

Lakemont treated with SO_2 maintained their quality and appearance well for the October marketing, but the untreated had considerable disease and rot, requiring additional time for sorting. None of the untreated grapes were marketable in November. Even fruit treated with SO_2 exhibited considerable berry drop and poor appearance and really were not marketable at that point. However, operators may not have had desirable temperature control in their storages due to frequent entry with other produce. Three to five times more Thompson seedless than Lakemonts was sold during the test periods. Principal consumer reaction after the test indicated that the small size of and unfamiliarity with the Lakemonts were the basic reasons for their not purchasing them. After trying the Lakemont, they were pleased with them.

Table 6. Average yield and expected ranges for five northeastern table grape cultivars.

Cultivar	Yield MT/ha	Range MT/ha
Festivee	18.6	10.7 - 26.3
Canadice	9.1	4.3 - 13.6
Himrod	6.8	3.4 - 10.2
Lakemont	4.3	3.0 - 6.1
Suffolk Red	4.3	3.5 - 5.7

Table 7. Berry weight and quality measurements for two northeastern table grape cultivars for the 1980-81 storage season.

Cultivar	Length of storage (days)	Berry wt (g)	Soluble solids (%)	pH	Titratable acidity (g/100g)	Soluble solids / Titr. Acid
Canadice	0	1.69	16.4	3.42	1.08	15.2
	30	1.84	16.7	3.35	1.07	15.6
	60	1.79	15.8	3.30	1.04	15.2
	90	1.86	15.6	3.40	1.00	15.6
Festivee	0	5.19	19.2	3.57	0.73	26.3
	30	5.51	19.2	3.75	0.66	29.1
	60	5.35	18.9	3.56	0.84	22.5
	90	4.50	18.3	3.52	0.78	23.5

Table 8. Effect of SO_2 packets on storage quality of two northeastern table grape cultivars during the 1980-81 storage season.

Cultivar	Treatment	Soluble solids (%)	pH	Titratable acidity (g/100g)	Soluble solids / Titr. Acid
Canadice	SO_2	16.0	3.33	1.04	15.4
	No SO_2*	16.3	3.35	1.04	15.7
Festivee	SO_2	18.7	3.51	0.80	23.4
	No SO_2	18.9	3.71	0.72	26.2

* Samples not available at 90 day storage interval.

SUMMARY AND CONCLUSIONS

Five table grape cv - four seedless and one seeded were stored in plastic liners at 1-2C up to 90 days. One-half of the fruit of each cv was treated with SO_2 packets. All cv stored well up to 30 days with or without SO_2. From that time forward SO_2 packets controlled mold and decay in all cv. Suffolk Red and Festivee fruit when treated with SO_2 remained in excellent condition throughout the 90 day storage period. Differences in quality factors were noted among cv and length of storage. Cluster stems of all cv tended to shrivel. In the case of Festivee stems became quite brown and shrivelled, but were not fragile. Himrod and Lakemont cluster stems were quite fragile, especially when handled at low temperatures. Although production problems still exist with Himrod, Lakemont and Suffolk Red, there appears to be a good potential for storing fruit of the cv under test in sealed plastic liners without SO_2 packets for one month. The use of one SO_2 packet per 9 kg of fruit successfully eliminated mold and decay in all cv as well as enhancing the condition of the fruit and cluster stems during storage.

Results of the first year's marketing study of northeastern seedless table grapes suggest a good potential for capturing about one-third of the present market for Thompson seedless. This may be increased as consumers become more aware of and familiar with these cv.

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APPLICATION OF ORGANIC PRINCIPLES TO SMALL FARMS

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ABSTRACT

It is fitting that we look to organic agriculture for clues on structuring the farming systems of the future and on the kinds of technology that might be applicable. Future systems must be more productive than those of today, but must have greater stability and efficiency. "The increases in productivity we can look forward to must find their source and inspiration from rational system design and management, not as was true in the past from cheaper and cheaper energy inputs." -- "In the long term, these results can be achieved through selective integration of unit operations and regional diversification, rather than continued differentiation, expanding scale, and regional specialization. Such systems capitalize on shorter transportation lines, closed material and energy loops, more stable ecological structures (reduced chemical pesticides), and shorter, less energy-intensive food-processing and distribution systems" (5). We will look briefly at the elements of organic agriculture, which may fit the requirements so clearly articulated by Edens.

Keywords: Organic agriculture, recycling, management, soils, nutrients, small farms.

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AREAS OF CONTRIBUTION OF ORGANIC PRACTICES

There are two main areas where organic agriculture may contribute to the solution to some of tomorrow's agricultural problems. The first is that organic systems are structured with extreme sensitivity to their environment. One of the guiding principles in enterprise selection as well as technology utilization is the need for protection of the soil resource, the health of farm persons and of organisms which share the farm environment. Many of the organic livestock producers, for instance, have switched from conventional to organic practices because of the health costs of their livestock operation, with the implication that non-conventional practices may reduce veterinary bills and lead to healthier livestock. This is a testimonial kind of data but one which is prevalent among organic practitioners. I'll not belabor the environmental issue further. Organic practitioners feel that close relationships exist between the biological condition of the soil, the health of farm animals, and farm family health. Much greater reference was given to this aspect in the USDA's report on organic agriculture (16).

The area of greatest contribution of organic practices to small farm agriculture is in the area of efficient utilization of production resources. I'll talk at some length about these areas of efficiency. They generally fall into two categories. First, there is efficiency of use of production inputs and secondly, the efficiency of utilization of capital inputs. Both of these areas of contribution are closely linked to farm structure with implications as to the "holistic" nature of an organic farming system. This leads us to a brief overview of organic philosophies and a short statement on the meaning of "organic" agriculture in the U.S. context.

ORGANIC PHILOSOPHIES

A perusal of organic literature will reveal on a worldwide scale several theories of alternative agricultural production. Several of these tend to be extremely philosophical. Others less so. The most comprehensive review of those theories is that of Boeringa (1). The various philosophies which are centered primarily in Europe include:

ANOG Agriculture
Lemaire-Boucher Agriculture
Macrobiotic Agriculture
Mazdaznan Agriculture
Organic-Biological Agriculture
Veganic Agriculture
Biodynamic Agriculture
Howard-Balfour Agriculture

Of these only the biodynamic agriculture and a derivitive of the so-called Howard-Balfour agriculture are found to any extent in the U.S. Biodynamic has a relatively small following here. The agricultural type which is most commonly found and is usually referred to in the U.S. simply as "organic agriculture" is that derived from the Howard-Balfour school. This is the agriculture described in the USDA's report on organic agriculture and is the one upon which I will comment.

Organic agriculture, along with all other biological agriculture types, is based on a system of agricultural production which works as much as possible in harmony with natural systems rather than making drastic revisions and replacements of those systems (7). One might argue that this is common to all agriculture, but it is really a matter of degree. In conventional agricultural practices, for instance, a large portion of our inputs and energy go toward restricting or eliminating natural growth processes rather than enhancing them. Pesticide use is an example of this. Conventional fertilizers, while increasing certain natural processes, will, depending on their concentrations, have a marked negative effect on soil microbial processes. Concentrated nitrogen and phosphorus forms are similar in this regard. The concept of maximizing ongoing biological processes in agricultural production is an important one. We will be referring to it at some length in the following discussion. One of the other key parts of Sir Albert Howard's contribution to organic practices is the structuring of production practices to achieve upward flow of nutrients in the soil profile over seasons. The organic system is based on this concept, differing from the usual result of conventional practices which lead to a downward flow of nutrients in the soil profile.

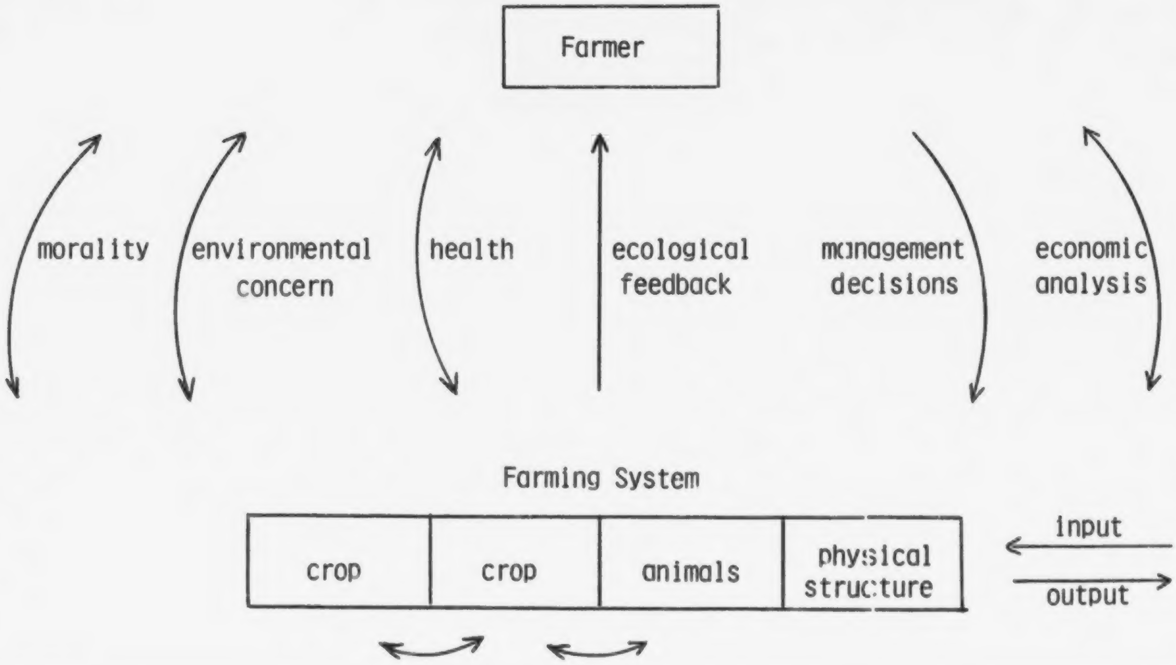
Organic agriculture as it is known in the U.S. centers first on inter-relationships between crop enterprises and perhaps between crop and animal enterprises within the farming system and secondly on nutrient flow. It is based solely on physical and biological principles as contrasted with several of the European schools which include more far-ranging theories. These principles are, for the most part, well documented scientifically. The major differences arise over the importance of biological processes stressed in organic agriculture which are less important in conventional farming.

MANAGEMENT DIFFERENCES OF AN ORGANIC FARM

In order to realize the efficiencies of resource use of an organic farm, structure and operation are extremely important. It must be emphasized that organic technologies are not simply a substitution of a "natural" or "organic" input for a manufactured or chemical one. The basic theory insists that the agricultural system be structured in such a way as to minimize the need for those inputs. A part of that whole process is minimizing or eliminating the use of any materials which are disruptive of those biological processes which the method is striving to enhance. Thus if a substance is disruptive, it makes little difference whether it is a naturally-occurring substance or not. It is not used.

The structure of an organic farm is illustrated in figure 1. In order to realize organic efficiencies, there must always be more than a single

Fig. 1 Structural Elements in Ecological Agriculture



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enterprise. These may be entirely crop enterprises or combinations of crops and animals. On most conventional farms, farm management is dependent mostly upon the relationship between inputs and production, or outputs. Optimum cash return per unit of input is the sole criterion for the productivity of the system. Farm management decisions are based almost entirely on this economic relationship on a "modern" farm. Farm-manager handling of an Illinois corn-soybean operation is a good example. The same economics govern organic systems but with additional inputs and elements entering into management decisions. Most organic farmers are keenly aware of environmental and health relationships of their family, their soil, their crops and the animals which they raise. Most of the structure of the system and the management decisions are influenced by those health relationships. These, oftentimes, temper economic considerations. In extreme cases one might hear organic farmers talking of these relationships in a moral or religious sense. Organic agriculture should not be confused at all with religion, however. It is based on purely physical, biological and scientific parameters where health and environmental considerations have become sufficiently prominent in the farmer's management decisions to constitute an absolute rule. A "religious" attitude may then seem evident, but the farmer is, nevertheless, working with a strictly scientific system in which morality plays a significantly larger role than in a purely economic system.

A crucial element of the organic system is the biological feedback from the system to the farm manager. This feedback can be most likened to the pest monitoring in a good integrated pest management (IPM) program. That careful monitoring of biological processes within the farm is essential to weed control, crop nutrition, and to pest management using organic methods. It is, thus, really a furtherance or extension of the IPM concept. In application it is very similar. Such feedback can be contrasted to the conventional continuous corn operation controlled by a bank manager in one of our corn belt states. In visiting such an operation, we found that fertilizer, pesticide inputs, seeding rates, dates of seeding, varietal selection and other management decisions were made by a person who had not visited the farm in over two years. Decisions were made strictly on the basis of technical formula and with input on current price and cost figures. There was no biological feedback in this system. None was needed. It has been "plugged in" when the "cookbook" recommendations were assembled. In such a system the efficiency of many natural biological processes are not realized. There is, thus, a major qualitative difference between management in an organic sense and the concept of conventional management based purely on economics.

We will now discuss some of those specific efficiencies.

EFFICIENCIES OF FARM STRUCTURE

Efficiency of structure of organic farms is not unlike that of a mixed-enterprise conventional farm. Combinations of enterprises are assembled to allow for efficient utilization of labor, machinery and facilities. There is perhaps more emphasis on use of small-scale machinery as a conscious decision rather than merely from the standpoint of economic limitations. The mixed enterprises not only permit but demand this intermediate to smaller scale equipment. The 320-acre organic farm neighboring the Rodale Research Center is farmed with a maximum tractor horsepower of 80. The maximum amount of tillage that is conducted is 90 to 100 acres prepared for spring corn planting. Since small grain, hay, soybean and other operations do not coincide with this, the 2 to 3 week tillage period is adequate using available horsepower. The same is true for the several small grains and the different kinds of hay that are used, all spreading out the operations. The number of tractor hours on the 80 horsepower unit in a year is far greater than on a 200 horsepower tractor on a much larger farm. Our neighbor to the west with his 2,000 acres of corn and 1,000 acres of wheat, for instance, has the corn acreage to cover in the same 2 to 3 week time period, and then, virtually nothing for the rest of the summer until harvest. The hours on his huge equipment per year are minimal even though he is farming ten times the acreage.

Enterprise combinations on organic farms are thus specifically designed for smaller-scale equipment wherever possible and for efficiency of nutrient flow and weed management. Even these may not be qualitatively different from some of the latest directions in mixed agriculture. Articles such as "The Rediscovery of Rotations" of a recent edition of THE FURROW magazine (9) indicate the rediscovery of the economic advantage to combinations of enterprises rather than continued reductions to a single crop. The net result of these efficiencies has been documented by the midwestern whole-farm analysis of Lockeretz et al. (11).

EFFICIENCIES IN NUTRIENT CYCLING

Organic systems are designed somewhat differently from those of conventional agriculture with respect to nutrient flow. The practices and the thinking behind structuring an organic system are to maximize the self-sufficiency and effectiveness of nutrient flow within a field. Second priority is then given to moving materials across the farm, and only as a last resort are materials moved in from off the farm. This is the opposite of modern thinking in conventional agriculture. The conventional model for crop fertility was essentially established by Liebig in 1840.

> "We could keep our fields in a constant state of fertility by replacing every year as much as we remove from them in the form of produce; but an increase in fertility and consequent increase in crop can only be obtained when we add more than we take away." (8)

One hears this same message repeated time and again in response to the challenge of organic practices. The conventional paradigm is based on "replacement" of harvested nutrients in order to maintain adequate levels of soil fertility. This maintenance is practiced on a crop-by-crop schedule with fertilizer being applied to replace that removed by the planned crop. We thus fertilize for 125 bushels or 150 bushels of corn. Others have questioned this simplistic concept (8, 10) proposing different paradigms. The organic methodologies are based on development of long-term soil productivity. In many cases the systems are very specifically designed on a whole farm basis as a mining operation, whereby release of nutrients from parent materials is maximized. This is identical to the mining being presently carried out in nearly all of conventional agriculture in the sense that there is a tremendous net deficit of nutrients in every field. It is much less in an organic field where erosion is controlled. In organic agriculture primary focus is placed on stopping erosion. Cover cropping, crop rotations and the use of leguminous crops minimize soil loss due to either wind or water erosion. In well-run organic systems, soil loss is reduced to approximately one-fifth the loss in continuous cropping (16). In a conventional field, for instance, where continuous corn is grown, using average soil loss figures, the gross outflow of potassium in a field will be between 400 and 600 pounds per acre with an average of 15 tons of soil loss due to erosion. Not all of this eroded potassium is in highly soluble form, but it nevertheless, over the long run, represents a net outflow from the field. Replacement values are calculated on the amount removed in the harvested crop. With an 80% reduction in erosion loss, the net potassium loss, with average crop yields, could be far less than in a conventional system even if no fertilizers were added. The problem becomes one of maintaining adequate soluble soil potassium rather than of maintaining a net balance of total potassium in the field.

In the long run organic systems where little or no added fertilizer is used will not deplete the soil to a greater extent than conventional agriculture. This is proven by soil test results on farms which have been in organic practice for many years as compared to those under conventional practices. On organic farms generally fewer nutrients are added to the farm as a whole than to conventional farms.

The key to maintenance of soil fertility in an organic system is the increased efficiency of nutrient flow from the fixed to the soluble or available state. There are several aspects of this in a complex system. First of all, the system is designed with rotations with deep-rooted crops to maximize the nutrient flow from deeper in the soil profile. There is thus a net upward flow of nutrients in the profile of both soluble and less-soluble nutrients, rather than the downward flow which is often found in conventional practice. Rotation with deep-rooted crops is one aspect of this upward flow. The avoidance of adding highly soluble nutrient sources is also part of the picture. The third aspect is the shallow tillage or complete avoidance of use of the moldboard plow. There is a growing amount of data from tillage experiments where moldboard is compared with chisel and zero tillage planting over long periods, all indicating that moldboard plowing hastens the downward movement of nutrients in the profile. In an organic system where crop residues are left closer to the surface any nutrients applied are applied to the top few inches; the soluble nutrients are maintained more readily in that upper part of the profile. An additional element is the conscious effort to maximize the flow of nutrients in an organic system through the insect phase rather than through the microbial phase or in applying nutrients directly to the soil water solution. As breakdown occurs or as nutrients are added, they thus go to a large extent directly into intermediate or a moderately available state rather than directly into the soil water solution. Getting the nutrients quickly into the plant, animal or microbial biomass maximizes the efficiency of retention. The availability pattern is different and slightly delayed and is somewhat temperature-dependent in this model.

The importance of the insect phase in nutrient flow is most prevalent in forestry entomological literature. There is growing interest in the amount that flows through the insect phase. In grassland ecosystems, the amount within the insect phase at a given time is small, but a significant proportion (perhaps up to 40-60%) may flow through that phase during the breakdown process (17). In organic systems a very conscious effort is made to maximize the amount of flow through both the insect and microbial phases. Soil inoculants are provided which (are supposed to) increase microbial activity in the soil. The rotation with legumes and the addition of manure greatly enhances microbial activity. It is very difficult with our present day analytical procedures to determine those amounts of microbial activity, but if mineralization rate can be used as one indicator, some organic systems are, indeed, extremely high. On the Research Center mineralization rates as high as 1800 pounds of nitrogen mineralized per year has been found in some of the fields using Pennsylvania State University analytical procedures.

As a result of this different model of nutrient flow, the resulting nutrient states are quite different in conventional from those of organic agriculture. Resulting organic matter in conventional fields is in a different soluble balance from that of organic fields. An excellent review of organic matter types and states is found in Hendrick (6). In a major experiment begun this year at the Organic Gardening and Farming Research Center, we designed a 9-treatment, 8-replication trial in a field which had been farmed conventionally for many years in corn and wheat. The organic matter levels in this field averaged 2.5% across 72 plots at the beginning of the experiment. Fields which had been farmed organically for many years on the Research Center itself, ranged from 1.6 to 2.4% organic matter. Tests of the organic matter of the conventional field (by Woods End Laboratory) showed that the organic matter was very stable with very little mineralization. Very little of the nitrogen in the organic matter was available for crop use. In this year's production, the formerly conventional field, when no fertilizer was added, gave corn flag leaf nitrogen at silking of 1.8%. Where fertilizer was added, the value was 2.9%. (2.8% is threshold level for adequate nitrogen in the crop to realize maximum yield potential) The organic fields (where organic matter content was significantly lower than in the conventional field) had flag leaf nitrogens of 2.73 and 2.74% indicating adequate nitrogen levels even though the organic matter levels were considerably lower. No fertilizer or manure was added to those corn fields. Previous experiments in those organic fields confirmed the adequacy of nitrogen. In 1979, replicated trials in organic fields indicated a response to nitrogen in only one field. One of the better soils in an organic field was in 3rd-year corn after alfalfa in 1979. The field had received no manure over the 3 year period. Average yields were 8.7 metric tons per hectare. There was no response to nitrogen in either organic or chemical form as measured across 5 rates of application and 4 replications. There is thus a much higher turnover of nutrients in the organic system. We are hypothesizing that with the net upward flow in the profile, the minimizing of erosion losses, that adequate nutrient levels can be maintained.

There is no argument that on some soils a significant nutrient input is needed. The argument is, however, that by using the organic model much greater efficiency of nutrient flow can be realized even on these fields. The efficiencies of the organic systems may, in fact, be much more important under low fertility than at high fertility. Under such conditions the incorporation of nutrients as rapidly as possible into the plant, animal or microbial stages is crucial to efficiency.

There are several elements which may be disruptive of this organic process. Tillage is very definitely one of them. There are no studies as yet on the effect of tillage in organic systems, but the different nutrient-flow model in no till-systems may be relevant. Doran (4) reports the microbial and biochemical changes associated with reduced tillage. Shams et al. (14) indicated the effect of no till on soil mesofauna. No-till comes relatively close to the organic model in certain aspects of effects on soil microflora and fauna, and on concentration of nutrients in the upper levels of the profile. The no-till model does not include the added benefits of reduction in pesticides.

Insecticides are extremely disruptive of soil microanthropods and of the detritivores which are important in an organic nutrient flow model. The effect of herbicides is much less clear (15). Certain herbicides such as ATRAZINE seem to be quite disruptive of soil microflora. Others seem less so, but this effect is apparently very much dependent on environmental conditions. Concentrated fertilizers are especially disruptive. Anhydrous ammonia is now among organic followers as being the most harmful. It is disruptive of the nitrogen flow pattern which is most desired in organic practice. The "hardness" of the soil resulting from continued application of these pesticides is probably the secondary effect brought on by reduction in soil insect and microbial fauna. A recent review of the use of nitrogen sources in organic agriculture has been done by Power and

Doran (13). This gives a relatively good overview of the nitrogen practices in organic agriculture, but does not deal at any length with the theories and philosophy.

There is at present considerable debate now being generated over soil testing, especially with reference to its applicability to organic systems. The BCR (basic cation saturation ratio) concept and the SLAN (sufficient level of available nutrients) debate is being reopened with intensity (2), with reference to the Liebig legacy. It is being suggested that present soil testing methods are based on field tests with strictly soluble fertilizers. It is becoming increasingly difficult to convert these recommendations for use with organic materials of "unknown efficiency." If we, in fact, shift to crop fertility systems striving for greater efficiency and perhaps using less soluble nutrients, we will have to eventually look to other soil testing methods.

EFFICIENCIES IN CROP/WEED BALANCE

We will not spend as much time on this section as on nutrient cycling. This is an important element, however, of organic agriculture. The weed/crop balance in an organic system is primarily influenced by crop rotation. An organic farmer will not plant into his field regardless of the weed population and simply select another herbicide to control the particular weed in the field. The rotation and crop sequencing are influenced by the weed pattern in the field. In long-term organic fields, some of the same weeds which plague conventional agriculture persist, but those typical of intensive herbicide single-crop enterprises are usually not as much of a problem in organic systems. With rotation being the key element in weed control, mechanical cultivation and good crop cover are then of secondary importance. Good fertility and optimum crop growth are also crucial to good mechanical and rotational weed control.

INSECT AND DISEASE MANAGEMENT

The relationships between organic management and insect and disease control have not been widely researched or not particularly well understood. There is a continuing philosophical chain in organic literature arguing that "plants grown in healthy soil, i.e., that soil which has adequate nutrient levels, good structure, and active soil microflora and fauna will be healthier and have fewer insect and disease problems" (3). If crops have adequate nutrients, they can certainly better outgrow insect and disease problems, but this does not necessarily explain why, as common observation seems to indicate, organically-grown crops have fewer insect and disease problems. There is no question that these problems exist. In organic field crops, at least, they seem to be minimal. With fruit crops, the problems are much more severe. There are instances of commercial organic fruit production, but here organic or naturally-occurring biocides may still be used. There is thought that in terms of insect control the higher levels of soil-borne insect fauna stabilize the insect populations of the system. The extremely high detritivore population in well-managed populations in well-managed organic systems serve as the food source for general predators. Those predator levels are then maintained at much higher levels in organic systems than in comparable conventional systems. The theory holds that fluctuations in insect pest numbers are thus modified. This entire area has not been well researched. There are many traditional remedies and treatments available for organic systems (18). These are, for the most part, very modest in their effectiveness. Many of them are applicable for very small-scale operations but not the larger ones. At this point, we must conclude that while organic systems seem to have fewer pest problems, the alternatives open to the organic grower in pest management are at present fewer. They require extremely careful pest monitoring and the maintenance of a delicate balance of pests and predators within the organic systems. Biological feedback from such a system must be effective, and detailed management decisions timely and very precise. Perhaps in the long run the natural stability of organic systems can be more widely capitalized on for pest management, but at present that whole area is less well understood.

FRUIT CULTURE

While this paper has been presented in a fruit culture section, organic agriculture probably is less well applied in fruit production than in other areas where biological stability is much easier to maintain. A recent book on organic fruit culture (12) is relevant primarily to the person with a small orchard for self-efficiency. There is some application to larger-scale agriculture but it is limited. There are a limited number of larger commercial organic operations in fruit production in the U.S., but their methods are less well known. For the most part, organic fruit production is mostly organic with some pesticides being only very occasionally used. There are large scale grape and pear production operations in the U.S. One grape operation in California has several hundred acres in organic table grape production. Information on these systems at present can only be obtained by direct contact with the growers. In each case they have been successful in eliminating or minimizing pest damage through a wide variety of practices including predator use, trapping, and in some cases limited use of naturally-occurring pesticides.

SUMMARY AND CONCLUSION

In summary we can say that organic systems or organic methodologies can contribute to small farms by:

1. Providing more effective use of capital investment through diversification
2. Shift the balance in the system toward greater return on labor than on capital (with the assumption that in small-scale systems capital is a primary limiting factor)

3. Efficiency of cash inputs and particularly of fertilizer inputs is much greater in organic systems. The cash requirements are far lower.
4. Rotations and intensive-management techniques are substituted for cash inputs for weed control and pest control.

In a system where land, capital, and production cash are the limiting input, the efficiency of those resources is maximized with an organic system. Considerably more management time is required but there is not necessarily a greater need for unskilled labor.

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SMALL FARMS SYSTEMS FOR EFFICIENT HORTICULTURAL PRODUCTION

Booker T. Whatley 1/

ABSTRACT

Agricultural Research and Extension in the United States are primarily the responsibility of the U.S. Department of Agriculture, State Land-Grant Universities, 1890 Institutions and Tuskegee Institute and to a much lesser extent, various other Federal Agencies, such as the National Science Foundation, which provides limited funds for Agricultural Research.

Small farms and small farmers are isolated sectors of American Agriculture. Since public production and marketing research and Extension Programs have been concerned primarily with farm output, they have tended not to focus on small farms. Limited resource (land) farmers are most difficult to reach by current Extension Programs. The USDA Programs over the past few years have been aimed at the entire rural community or have looked at small farmers simply in terms of production. A consequence of this approach has been a lack of support for small farmers.

The Tuskegee Small Model Farm Plan grew out of our Sweet Potato, Small Fruits and Honey Bee Research Programs and are designed to assist farmers who own from 25-150 acres of land, who are presently attempting to produce corn, cotton, soybeans, peanuts, hay, beef cattle, etc.

Keywords: Cash flow, farm output, farm plan, labor requirements, limited resource farmers, marketing, minimum income, rural community, small farms.

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The Tuskegee Small Model Farm Plan consists of nine (9) crop components and sixty (60) colonies of honey bees. This twenty-five acre farm is a Pick-Your-Own operation with a Clientele Membership Club, Associated. Sweet Potatoes and Honey Bee Products are not Pick-Your-Own Components. This farm will provide fruits, vegetables and honey bee products for one-thousand (1000) households or approximately five-thousand (5000) persons. It is essential that irrigation be provided for each Crop Component. The production of crops should be produced under minimum constraints and a high level of management employed in the production of honey bee products. The farm should be located on a hard surface road, with a source of water (well, pond, stream) and within a twenty-five (25) to forty (40) mile radius of a population center. The labor requirement for this farm is 2.5 man years.

The Components of the Farm are:

1. BLACKBERRIES	1.0 Acres
2. BLUEBERRIES (Rabbiteye)	2.0 Acres
3. COLLARDS	2.0 Acres
4. MUSCADINE GRAPES	5.0 Acres
5. MUSTARDS	1.5 Acres
6. SOUTHERN PEAS Shelling Service	5.0 Acres
7. STRAWBERRIES	1.0 Acres
8. SWEET POTATOES	5.0 Acres
9. TURNIPS	1.5 Acres
10. HONEY BEES	1.0 Acres/60 Colonies
TOTAL	25.0 Acres

The five (5) criteria for the success of a small farm operation are:

I. The Components must provide year-round weekly family income. With early, mid-season and late maturing cultivars, Strawberries will provide the cash-flow from mid-April to mid-May. Blackberries will provide the family income from mid-May to mid-June and Rabbiteye Blueberries from mid-June to the end of July. One acre of the five (5) acres of Sweet Potatoes are harvested and sold green (without curing) from the last week in July to mid-August. Muscadine Grapes are available for sale from mid-August thru September. The remaining four (4) acres of Sweet Potatoes are harvested in October, cured and sold on a weekly basis from November 1 to mid-April. Spring and Fall crops of Southern Peas and Greens are produced. Southern Peas provide cash-flow June, July and October. Greens (collards, mustards, turnips) provide cash-flow April and May and October thru December. The Honey Bee products consist of honey, beeswax, propolis, pollen, royal jelly, and pollination service. These products will be available year-round.

II. The Components of the Farm must be compatible, that is, they should not compete with each other for harvest labor. Year-round cash-flow is provided with this plan. There is some overlap in crop sales from April thru July and November and December. This overlap is manageable and desirable plus the Component compatibility is excellent.

III. Each Component of the Farm must produce an annual gross minimum income of $3000/Acre/Year. This guideline points out those crops and enterprises in which limited (land) resource farmer should not be engaged. The small farmer should engage in the production of high value crops and enterprises that gives a high return per acre. This guideline eliminates such crops and enterprises as corn, cotton, soybeans, peanuts, hay, beef cattle and swine.

IV. The Farm must provide year-round and full employment. The labor requirement for this farm is 2.5 man years, (man, wife, and three teenage children). To work part-time or full-time off the farm is to invite disaster.

V. Markets for the commodities produced must exist in nearby population centers ... Pick-Your-Own with a Clientele Membership Club, Associated. A Pick-Your-Own operation eliminates the cost of harvesting, washing, grading, package containers, packaging, refrigerated storage and transportation to market. It also eliminates the one major complaint of small farmers ... the lack of available markets. The farmer establishes his or her own Clientele Membership Club by seeking out and requesting individuals to join his or her Club. The Clientele Membership Club should consist of the heads of one-thousand (1000) households. The annual membership fee is $25.00 and gives the member and his family the privilege of coming on the farm and harvesting all commodities except Sweet Potatoes and Honey Bee products at approximately 60% of the supermarket prices. The Clientele Membership Club must be promoted. If one fails to promote something terrible happens ... nothing! If land is available and a suitable irrigation pond site is located (USDA/SCS), we recommend that an irrigation pond be constructed and stocked with fish and selling of fishing rights. If fishing rights are sold, the Clientele Membership fee should be increased to $40.00 annually. The management of the irrigation/fish pond should include the appplication of forty (40) pounds of 20-20-5 fertilizer per month, per acre of pond surface from February 15 thru October 15 and adjusting the water to pH 7.5 to 9.5.

HOW-TO-DO type bulletins are being developed for each Component including budgets. These publications will be available from Plant and Soil Sciences, Tuskegee Institute, Alabama 36088, 205/727-8446.

By the end of the 5th year this farm will be grossing well over one-hundred-thousand dollars ($100,000.00) annually.

MINOR USE PESTICIDES

Paul H. Schwartz 1/

J. Ray Frank 2/

ABSTRACT

The IR-4 program was initiated in 1963 in response to concerns over the lack of registered pesticides for minor crops or minor uses. Historically, this program has developed data for tolerance setting of pesticides. In 1976 the program expanded and became involved in developing data to support registration on nursery and floral crops. The National headquarters for the program is at the New Jersey Agricultural Experiment in New Brunswick, New Jersey where the State/Federal/Industry effort is coordinated. State and Federal scientists develop efficacy, residue, and phytotoxicity data which are used to obtain tolerances from EPA and to amend existing pesticide labels in cooperation with the registrant. State and Federal support for the program is about $8.0 million annually and is used to develop the data for the approximately 1,900 food requests and 8,000 ornamental requests in the IR-4 system. Currently about 55 scientist years, 36 professional support scientist years, and 50 technical support years are invested in the program.

Keywords: Efficacy, EPA, fungicide, herbicide, insecticide, IR-4, nematocide, residues, registration, small farms, tolerances

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American agriculture is an important sector of the U.S. economy. To thrive it depends on chemical pesticides to control the pests that continually compete with man for his food and feed supply. Our farm industry provides an enormous potential market for agricultural pesticides. For instance, in 1979, there were 2.3 million farms in the U.S. with an average size of 450 acres. The total farm population in 1979 was 6.2 million people representing 2.8% of the total population. Gross farm income was over $149 billion. Cash receipts from farming totaled $133 billion. Of this total, $62.8 billion was attributed to direct farm receipts for crops. We have an excess of domestic agricultural exports over agricultural imports of $22.9 billion which provides a major positive contribution to our balance of payments to foreign countries (17).

Need for Pesticides

The agricultural sector must continue to grow and prosper. However, pests continue to be an impediment to agricultural production in the U.S. There are an estimated 600 species of harmful insects, more than 1,500 diseases caused by fungi, viruses, and bacteria, about 1,500 species of nematodes that cause damage to crop plants, and 1,800 weed species that cause serious economic losses.

Losses caused by these pests vary from year to year and from location to location. Thus, losses are difficult to quantify, but some authors have made attempts to estimate losses caused by pests. In 1979, the Federal Crop Insurance Corporation provided indemnities for hazards caused by insects and diseases. Of the total payments made from the period 1939-1979, 4.3% were attributed to insects and 2.8% were attributed to disease. The Federal Crop Insurance Corporation did not specifically indicate any indemnity payments attributed to weed losses. James (8) estimated the losses caused by plant diseases for the major crop groups in the U.S. to be about 6.4% annually. Palm (12) estimated, that without fungicides and nematicides, disease losses would range from 7% to 29%. Schwartz and Klassen (14) estimated losses due to insects to range from 7.4% to 14.8%. Chandler (3) estimated losses due to weeds in all crops to be 11.7%. Abernathy (1) estimated that the elimination of herbicides and use only of economically feasible nonchemical means of weed control would reduce annual farm revenue by 31%.

Pesticides are essential in protecting our valuable agricultural industry. We estimate continued losses caused by pests and cost of control to be over $45 billion annually. Of the $15 billion portion of this spent on pest control, about $7.6 billion is spent on chemicals and their application. The remaining $7.4 billion is spent on various nonchemical control methods including tillage for weed control.

Volume of Pesticide Use

Eichers (6) calculated that the quantity of pesticides purchased by farmers in 1980 was 846 million pounds compared to 353 million pounds in 1966. He indicated that corn, cotton, soybeans, and wheat accounted for 85% of all herbicide use and 70% of all insecticide use. Information on diseases and nematodes was not supplied. Herbicides accounted for 67% of the total pounds of pesticide use, insecticides - 20%, fungicides - 6%, and all others, 7%. However, pesticides accounted for only 3% of the farmer's total production expenditures. Total expenditures by farmers in 1980 for pesticides were $3.6 billion compared to $561 million in 1966 (6).

History of Pesticide Regulation in the U.S.

Pesticides were first regulated in the United States under the Insecticide Act of 1910, which was administered by the Bureau of Entomology of the U.S. Department of Agriculture (17). Problems with pesticide residues began to emerge around 1919 because of concerns of heavy deposits of lead arsenate on fruits. Standards for insecticide residues on food were first initiated in the mid 1920's. This action was taken under the regulatory statue of the Food and Drug Act of 1906 which was administered by the Bureau of Chemistry, USDA.

In 1930 the Food and Drug Administration (FDA) was transferred from the USDA to the Federal Security Administration which in 1953 became the Department of Health, Education, and Welfare. The Federal Food, Drug, and Cosmetic Act of 1938 replaced the Food and Drug Act of 1906 and provided additional regulatory authority over residues in food (5).

The Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) was passed by Congress in 1947 followed in 1954 by the passage of the Miller Amendment to the Federal Food, Drug, and Cosmetic Act. In 1970, administration of FIFRA was transferred from the USDA to the newly formed U.S. Environmental Protection Agency (EPA). Two years later, FIFRA was amended to give EPA broad, new powers over pesticides. FIFRA was further amended in 1975 and again in 1978.

The pesticide industry has experienced the direct impact of regulation through the loss of pesticides and increased cost to retain others. The establishment of a requirement for "No residue" on food crops prior to registration prevented the use of many pesticides on important minor crops, thus creating serious pest control problems in these crops. Estimates of the cost of placing a new pesticide on the market now ranges between $12 and $15 million, and 5 to 10 years is required before a new product reaches the market place. This partially reflects inflation, but represents a 6-10 fold increase over 1970 (2). The U.S. International Trade Commission (16) estimated that research and development costs for a new pesticide in the U.S. are currently between $20 and $30 million a year because of extensive screening processes and environmental and toxicological data required before it can be placed on the market. In addition, the cancellation procedures administered by the EPA for the chlorinated hydrocarbon insecticides and EPA's subsequent development and enforcement of the RPAR process (Rebuttable Presumption Against Registration) have resulted in the loss of a number of registered uses of pesticides.

The Creation and Development of Interregional Research Project No. 4

As pesticide regulations increased with a subsequent increase in development and registration costs, the pesticide industry concentrated their resources on the major volume uses. Officials in the agricultural sector of both the Federal and State governments foresaw, as early as 1962, that tolerances would not be obtained for many essential chemicals that were nonproprietary or were applicable only to limited geographical areas of specialty crops. Accordingly in 1963 they established a cooperative program of State and Federal agencies known as IR-4 (Interregional Research Project No. 4 entitled "A National Agricultural Program for Clearance of Pesticides for Minor or Specialty Uses"). These specialty uses include pesticides for all fruits, vegetables and other specialty crops grown in the United States and its possessions. IR-4 was organized and funded under the Research and Marketing Act regional research funds as an interregional research project. These funds are made available through the Cooperative State Research Service (CSRS) of the USDA and the State Agricultural Experiment Stations (SAES).

The IR-4 project was charged to identify critical problem areas where agricultural production was vulnerable to disastrous losses from uncontrolled pests, to work with the state experiment stations in the collection of data not otherwise available, to establish tolerances that would lead to registration, and to serve as a coordinating interface between public research workers, regulatory agencies, and pesticide registrants.

To accomplish these objectives, the IR-4 project established a central office or National "headquarters" at the New Jersey Agricultural Experiment Station in New Brunswick on the campus of Rutgers University, and project coordinators with research experience in weed, plant pathogen, insect, and nematode control were hired to collect and develop data to be submitted for pesticide registration. The operation of the IR-4 headquarters office was guided by a committee comprised of administrative advisors from the Northeast, North Central, Southern, and Western geographical regions; four technical scientists or representatives from each of the four regions, and consultants from Federal agencies (USDA and EPA) and the pesticide industry. Additionally, each state agricultural experiment station director appoints a state liaison representative to work with IR-4 headquarters and researchers in his state to identify pesticide registration needs. A USDA weed control specialist, an entomologist/nematologist, a plant pathologist, and a research chemist were also appointed as liaison representatives from each of the four regions. In 1974, EPA established the position of minor uses officer in the Registration Division to handle the petitions from IR-4.

As a result of the IR-4 project, the use of land, equipment, and facilities of the SAES were made available to meet some of the registration research needs. More importantly, the professional expertise of the public agricultural science community was made available for minor use studies. For example, a scientist who is already uniquely familiar with a particular problem on a minor crop can generate the precise field data and residue samples needed for registration in the locality where the problem exists.

In both 1976 and 1977, increases in funding levels were appropriated for minor use pesticide clearance by the U.S. Congress. These funds amounted to approximately a $2 million increase over the budget for fiscal year 1975. We estimate the total effort for registration of minor use pesticides in SAES and USDA to be $8.3 million annually. Research funds to supplement State and Federal scientists working with the IR-4 Project amount to $1.5 million for CSRS and $1.1 million for the Agricultural Research Service (ARS). In addition, the SAES provides about $4.1 million and ARS about $1.6 million in support to the IR-4 program in salary, housing, land and equipment. Currently, about 55 scientist years, 36 professional support scientist years, and 50 technical support years are being utilized in the program.

IR-4 Reorganization

In 1976, the IR-4 program was reorganized throughout the State-Federal system. A regional pesticide residue analysis laboratory was established in each of the four regions and funded with the increases from the U.S. Congress. A new technical committee was established consisting of each of the directors of the four laboratories and the coordinator for the ARS program. Simultaneously, ARS established a special research program to develop data to register pesticides for minor uses.

In 1976, the IR-4 program for the first time initiated registration projects necessary to meet the needs of the floral and nursery crop industry. In 1976, EPA established a position at the IR-4 headquarters to assist with the development of data to establish tolerances.

Also, in 1976, IR-4 headquarters took several steps to strengthen its capability for coordinating the greatly expanded IR-4 program without increasing staff personnel. Various "bookkeeping" forms were devised to expedite the initiation of projects and recording of data (i.e., pesticide clearance request forms, efficacy report forms, residue report forms). With the tremendous increase in the total number of projects handled by IR-4 after 1976, these forms did much to standardize recording of data for use in managing projects and preparing petitions. A computerized system was subsequently developed by IR-4 headquarters to track projects and reduce the bookkeeping involved even further to permit the monitoring of the current status of each project. Currently, there are about 1,900 food uses and 8,000 ornamental uses in the computer system.

In 1977, the IR-4 program established a one-year program to determine the magnitude of the minor use problem with emphasis on floral and nursery crops. A minor use analyst in each of the four agricultural regions met with State and Federal representatives in extension, teaching, research, and allied agricultural organizations to develop the needs for minor use pesticide registrations. This was a highly successful program which disclosed approximately 6,000 needs in ornamentals, as well as several hundred additional needs in food crops.

Finally, in 1978, the IR-4 headquarters staff was reorganized. The position of National Director was established to provide better coordination between Federal, State, and industry workers relating to the development of data to register minor use pesticides.

Scope of IR-4 Research

A number of categories of data are required for pesticide registration. These include efficacy, phytotoxicity, residue chemistry, product, and environmental chemistry, product hazard, and toxicity. The IR-4 program is involved primarily with obtaining data on efficacy, phytotoxicity, and residues. It is the responsibility of the chemical companies and/or other registrants to obtain data on the other categories. IR-4, therefore, can only work with products that have at least one registered use and generates those residue data necessary to establish a tolerance which is the level of residue permissible for use on food crops. These data are developed under scientific protocols which have been written in cooperation with the scientists conducting the research, the EPA, the registrant, and the IR-4 headquarters staff.

Accomplishments of the IR-4 Program

From its inception in 1963 to October 1, 1976, the IR-4 project was instrumental in the development of data to obtain clearances for 2,479 research projects or about 191 clearances/year. Prior to 1976 these clearances for the most part were extensions of existing State labels. A strict enforcement of the FIFRA amendments was instituted following the creation of EPA. This greatly reduced the number of clearances obtained each year. In 1976, 20 tolerances were established for National labels; however, in 1977, only three tolerances were established because of a near stoppage in registration of pesticides by EPA. However, 22 tolerances were established in 1978, 20 in 1979, 19 in 1980, and approximately 30 in 1981.

The data packages submitted to EPA for ornamentals have been reviewed in record time by the Office of Pesticide Programs to establish 1,096 label registrations since 1977. This encompasses about 4,600 minor use ornamental crop species.

The funding increases and organizational changes within IR-4 and the support of minor use pesticides research within ARS have helped the IR-4 Program to gain significant momentum and to generate a large amount of data from research programs. Many of these data have not yet reached the petition stage. Through cooperative efforts with the pesticide industry and EPA, these data will be used to gain many new minor use pesticide registrations in the near future, thus alleviating some of the critical needs for chemicals to control pests on minor crops. Once this backlog of minor use needs is resolved, IR-4 can devote appropriate support to the development of data for registration of the many important specialty materials urgently needed in Integrated Pest Management (IPM) Programs which have not been registered previously. These materials include, insect attractants, hormones, pathogens for diseases of insects and weeds, pheromones, and other behavior-modifying chemicals. Because of their limited spectrum of activity and low volume usage, little economic incentive exists for registration of these materials by industry. However, these very attributes make them attractive because of their "softer" environmental impact. The data requirements for registration, however, will be similar to those for conventional pesticide materials. (EPA is currently working on registration guidelines for these important IPM materials.)

Thus far, ARS has developed four draft biorational pest management petitions and submitted them to IR-4 for subsequent review and submittal to EPA and FDA. These petitions were developed to establish exemptions from the requirement of a tolerance for the following:

1. The use of CO_2, N_2, and combustion gas products to control insect pests on raw and processed agricultural commodities (established in 1980).
2. The use of gamma radiation to control insects on raw agricultural commodities (under FDA review).
3. The use of malathion and methyl eugenol to control the Oriental fruit fly (under EPA review).
4. The use of alfalfa looper virus on cabbage and lettuce (under EPA review).

From 1976 to 1980, ARS also contributed data on efficacy and phytotoxicity for 205 food use projects, for residues for 138 food use projects, and phytotoxicity and/or efficacy data for 1,682 ornamental use projects.

Specialty or minor crops are grown on nearly all of the small farms in the United States. In a survey taken of small farms in the Northeast Region (10) vegetables alone ranked third in cash value of all products sold by the small farmer.

Here are a few specific examples of how the IR-4 program assists the American small farmer by reducing specialty crop losses attributed to pests:

Captafol, which is used for control of anthracnose and other plant diseases on blueberries, has increased the marketable crop yield by 2 to 3%. Even though these figures are considered conservative, this one pesticide registration has increased farmer revenue in one state alone an estimated $80,000 to $120,000 annually (15).

Lannate, which is now registered for the control of aphids, mites, and shuckworms on pecans, now saves the American pecan grower an estimated $1.9 million dollars annually (13).

Weed control using glyphosate herbicide in cranberry bogs has been estimated to increase crop yields 10 to 15%. This can result in an increased profit of $6 to $10 million dollars annually. With this herbicide and the new application methods now available, the small farmer could realize a $1,000 an acre profit increase each year (18).

Alachlor, glyphosate, metolachlor, napropamide, oryzalin, oxydiazon, and simazine have now been registered for use in weed control in ornamental crops. The availability of these compounds for weed control in ornamental crops has reduced annual crop losses an estimated $20 million dollars (4, 7).

The withdrawal of DBCP from the market has caused a major void in the nematode control program in snapbeans. Nearly 38,000 acres of the snapbeans in the United States need to be treated with an effective nematacide. Yields are reduced in nematode infested fields by one third. A new nematacide, phenamiphos for which data are now being collected, is estimated to effectively control nematodes in snapbeans and thus increase profits by $8.5 million annually (9).

Bentazon was registered for weed control use in both peppermint and spearmint. With this product the farmer realizes an increase in profit of $140/acre or a national savings of $680,000 per annum. Yield of mint crops is reduced 50% without the use of bentazon to control perennial weeds (11).

These selected examples demonstrate that ARS and the IR-4 program have contributed substantially to the improvement in the management of pests affecting agricultural production on both small and large farms. These contributions are particularly important to specialty crop production on small farms.

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SYNOPSIS OF EUROPEAN SMALL FRUIT ENTERPRISES

Kurt Russ [1]

ABSTRACT

European fruit production has always been based on the concept of small farm management. Farm size averages between 2-50 hectares and only very few enterprises exceed a size of 100 hectares.

A few examples from Austrian fruit-growing show how the European pest management system attempts to take new pathways towards greater efficacy and to explore new control methods for various problem pests. The diversity of topographical regions, climatic conditions and fruit varieties will not allow uniform solutions to pest management problems.

Keywords: Agriculture, agricultural enterprises, European small farm management, forecasting of pests, integrated pest management, small farms, statistics.

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INTRODUCTION

Compared to agriculture in the United States, European agriculture is characterized mainly by economic units best described by the term "small farms". One seldom encounters agricultural complexes as large as 100-200 hectares, and if so, these are primarily cereal- or sugar beet-producing enterprises.

As far as fruit production is concerned, it is evident that small enterprises prevail with the exception of Southern European areas as well as Eastern Europe (Hungary, Romania, Poland, Bulgaria, Czechoslovakia, and the Soviet Union) . Fruit-producing agricultural units seldom exceed a size of 10-15 hectares, and farms of 5-10 hectares predominate.

In many cases the agricultural income of such "smallest farms" does not suffice to feed adequately a family of 4-6 persons. These land-owners therefore often hold second jobs (Saturday-Sunday farmers).

To insure an adequate income despite small farm dimensions, some land-owners attempt to raise special crops that combine low investment costs with high-value, quality production. Fruit and vegetable production meet these requirements.

These farmers must primarily try to keep the costs of farm workers and production means as low as possible. Nevertheless, steadily rising wages and the rocketing costs of fertilizers and agricultural chemicals make it increasing difficult for small producers to reduce expenditures and still make an adequate profit.

In the last few years it has become increasingly evident that most farmers compute costs exactly for personnel and production means (fertilizers, agricultural chemicals) as well as for machinery and its utilization in their production analyses. They, therefore, desire primarily to reduce the use and thus the costs of agricultural chemicals and to lower employee wages.

This development is being observed carefully by national and private institutions responsible for agricultural production, and necessary measures are being taken with respect to this trend. In the course of my address I shall deal with some of these measures, at least with those concerning plant protection.

PRODUCTIVITY, MACHINE UTILIZATION AND POTENTIAL OF AGRICULTURAL WORKERS IN EUROPE

A comparison between productivity, machine utilization, and the potential of qualified agricultural workers in fruit or vegetable production in different countries will allow an evaluation of a given nation's agricultural structure: does it belong to the group with "large farms" or to the group with "small farms"?

Table 1 shows clearly that Europe still cannot compare to the United States in regard to the number of tractors. But it must be mentioned that Europe, with its numerous small farming enterprises, does not need to increase its tractor stock. Neither the dimensions of these small farms nor their economic return are suitable for such development. As far as can now be foretold, this situation will not change in the near future.

Table 1. Percentage of Various Agricultural Populations and the Number of Tractors Utilized in 1978

Location	Agricultural Population	Tractors Utilized per 1000 people
World	46.4 %	9.8
USA	2.4 %	846.0
Europe	16.3 %	104.7

At this time there are on the average 104 tractors per 1000 persons employed in agriculture in Europe, compared with 846 tractors per 1000 persons in the United States(FAO Yearbook, 1979). This statistic alone shows clearly that European agriculture consists primarily of "small farms." These small enterprises are in general necessarily more employee-intensive, i.e., the land-owner and his family do a large part of the work themselves and rely to a lesser degree on agricultural machines.

The percentage of the population engaged in agriculture also clearly demonstrates the "small-farm" character of European farming enterprises. In Europe, 16.3% of the population is employed in agriculture compared with 2.4% in the United States. This fact shows Europe to be an area with predominately small-farm structure.

My native country, Austria, belongs to the group of European nations particularly characterized by a small-farm structure. The reasons for this structural arrangement are perhaps due not so much to an economical or agropolitical nature, but stem rather from existing topographical factors. The highly structured landscape with predominantly hilly and mountainous regions, as well as the resulting traditional socio-economic parameters, impede the evolution from small-farm structures to larger agricultural units. Larger enterprises have been established only in eastern Austria, a flatter country which is part of the Great Hungarian Plain, where field crops, and not fruit production, prevail.

Because of its manifold agricultural structure, Austria is typical of the European way of farming and can serve as an example for further discourse. Austrian agricultural problems, e.g., those concerning fruit production, are essentially the same as those in all other European countries. Perhaps it can, therefore, be legitimately presumed that the Austrian situation is representative of many other European countries, and that a description of Austrian agricultural conditions will also indicate the general European trends.

FARM SIZE IN AUSTRIA

The Austrian agricultural population during 1980 was approximately 760,000 or about 10% of the resident population of 7,506,000. As already shown, agricultural units in Europe, with few exceptions, cannot compare with the proportions of large farms in the United States. This is shown in detail in Table 2 which shows the size distribution of Austrian agricultural enterprises.

Table 2. Austrian Agricultural Land Usage in 1980

Cultural Use	1,000 Hectares	Percent
Arable land	1,488	39.7
Vegetables, Fruits	89	2.3
Grapes	57	1.5
Meadows	1,010	26.9
Pastures	225	6.0
Alpine pastures	872	23.3
Total	3,741	99.7

It follows that not only is the fruit production area very small in comparison with other agricultural land-uses (only 2.3% of the total acreage under cultivation), but that agriculture is also highly structured with a predominance of small enterprises. Almost 80% of all Austrian farms are smaller than 50 hectares, and there is only a very small number of large enterprises. Conditions are also similar in the majority of other European countries.

FRUIT PRODUCTION IN EUROPE

In connection with these facts we must now raise the question as to how small enterprises, such as those prevailing in Europe, are able to achieve adequate fruit production.

It would certainly be too time consuming to enumerate fruit production statistics for all the European countries and all fruit crops on this occasion. I will therefore compare crop yields for only the most important European fruit-producing countries in comparison to those of the United States and to average world crop production. It shows, for example that relatively higher per capita yields are obtained in certain fruit crops in Austria than in the United States, for example, pears, peaches, and plums. In general, however, per capita yields are very similar. These facts can perhaps demonstrate that despite, or maybe even because of the predominance of small farm units with their high degree of specialization, their establishment in areas of optimal climatic conditions, and their well-developed agricultural practice, high yelds can be achieved.

WHAT MEASURES ARE TAKEN IN EUROPE TO ENSURE SUCCESSFUL SMALL FARM MANAGEMENT?

It is evident that the European agricultural situation, especially fruit production as related to management, needs adequate measures to ensure successful management.

As has already been shown, European fruit production is characterized by relatively small agricultural units. This situation requires appropriate organizational forms adapted to these special conditions. It also follows that because of diverse topographical and climatic conditions, management procedures require a high degree of adaptability to individual production circumstances. In other words, European fruit production has always been characterized by small farm management.

Within the scope of this synopsis it is practically impossible to go into details concerning such management procedures. As representative of all other European countries, I shall describe the situation in Austria. This course seems legitimate, as the structural circumstances of Austrian agriculture, especially as it is related to fruit production, greatly resemble those in other European countries.

Small Farm Management in Austria

Production prerequisites

An intensive climatic zonation has allowed Austrian fruit producers to grow their fruit varieties in regions with optimal growing conditions. Pome fruit is grown at nearly all altitudes (130 - 900 meters above sea level). Apple, pear, peach, and black currant are preferably grown in Styria (250-700 meters above sea level). Apricot, cherry, and strawberry grow best in the pannonic "vineyard climate" of Burgenland and many areas in Lower Austria. Plum, raspberry, and strawberry are chiefly grown in cooler regions, e.g., in the alpine foot-hills, in northern Lower Austria, and in Upper Austria.

Marketing

Since the end of the World War II and the subsequent "Small Green Revolution," Austria, as well as many other European countries, has to a large degree become agriculturally self-supporting. As far as fruit production is concerned, my country can satisfy approximately 70% of its fruit consumption needs internally (1979-1980) . This means that Austria can also export certain fruit varieties (apples, apricots, and black currants at a value of about 50 million Austrian schillings = 3 million U.S. dollars).

A very important prerequisite for the attainment of such a high degree of self-sufficiency was the great improvement in fruit storage achieved within the past few decades. Thirty-five warehouses with a storage capacity of approximately 50,000 tons have been erected to date. Difficult marketing possibilities, resulting from the small size of the individual fruit-producing enterprises as well as from unfavourable topographic conditions (dispersed orchards), called for regional cooperation among farmers at a very early date. It was, thus, possible for the individual farmer to avoid the risks of self-marketing and to set fair prices for both producer and consumer. These cooperatives are self-governed by the members (farmers) and are subsidized by grants and credits from federal (Department of Agriculture and Forestry) and state (State Department of Agriculture) institutions.

A so-called "Quality-Grades Law" guarantees not only the farmers a satisfactory sale of their products but also guarantees the consumers high quality goods.

Numerous cooperative and individual activities have been established to give the farmers assistance, e.g. with the planting of new orchards or with the procurement of favorably-priced means of production (fertilizers, agricultural chemicals, marketing equipment, etc.).

Pest Management

The often-mentioned heterogeneity of Austrian (and European) fruit production has resulted in the adaption of pest management procedures to specific individual problems in the same way as fruit-growing procedures as a whole are geared to individual production requirements. This resulted in the establishment of regional pest management many years ago, where pest management procedures are adjusted to the special needs of various production areas.

The modern form of Integrated Pest Control, promoted in Europe by International Organization for Biological Control/West Palearctic Regional Section, is therefore excellently suited to Austrian conditions (and the conditions in other European countries as well). This control system is strongly supported by national authorities as well as by semi-official and private institutions.

Forecasting in Pest Management

Decades ago Austria began to initiate forecasting and prognosis facilities for an optimal pest management program. Many very important, fundamental research projects toward integrated pest management were conducted by the scientists of the Federal Institute for Plant Protection in Vienna.

As early at 1958, the installation and subsequent expansion of a forecasting system for codling moth (Laspeyresia pomonella) was initiated by developing a closely-meshed network of light-trap stations. This system replaced the wasteful and often inadequate traditional control methods for codling moth. The number of pesticide applications against this pest could thereby be reduced from 10-12 to only 2-3 per year.

The control of apple scab (Venturia inaecualis) is still very difficult, but by means of the development and construction of a relatively simple apparatus, the "leaf-wetness counter" (Zislavsky, Federal Institute for Plant Protection), control is now considerably improved. This means that apple scab control measures in many regions can be performed prophylactically and, thus, much more effectively.

An apparatus was constructed to register effective temperature sums, which allows the continuous summation of temperatures above which pest development takes place, thus allowing the forecasting of important development stages of different pests (e.g. codling moth).

The transmission of information important to agriculturalists and especially to fruit producers concerning necessary plant protection measures is conveyed over radio as well as by telephone and postal services. It is, thus, ensured that important information is rapidly received by the producers.

Legislative Measures

All European countries have special regulations governing the sale and use of plant protection chemicals. Although these regulations may have different patterns according to the country, the contents and purpose are very similar everywhere. In Austria, for example, regulations for the protection of cultivated crops were passed by Parliament in 1948, and subsequently often revised. A new law, better adapted to present conditions, is now being drawn up.

Besides this legislation, special regulation governing tolerance levels in harvested products also exists in practically every European country. Therein the highest acceptable residue levels in harvested products after use of pesticides are exactly defined. To ensure that no unduly high residues remain on foodstuffs after pest control measures, scientifically determined intervals are established for the minimal time-lapse between application of certain plant protection chemicals and crop harvest.

Information and Training

Pest management systems based on the diversity of small farm units require much more intensive information and training of individual farmers than is the case for larger agricultural enterprises. Most European nations, therefore, conduct specialized courses for small groups of fruit-growers from the same agricultural region. This method of transmitting pertinent information, as well as the personal training inherent in this form of education, has guaranteed good success, especially with respect to integrated pest control measures. New or specialized plant protection methods are often demonstrated on selected "show farms" to promote their more general application.

The baseline work for such continuous extension service is conducted in the research departments of the appropriate applied institutes. New knowledge obtained there is popularized and incorporated into the extension service as soon as possible.

SPECIAL PEST MANAGEMENT PROBLEMS IN EUROPEAN FRUIT PRODUCTION

Besides the occurrence of traditional pest complexes (e.g. codling moth, aphids, scales, apple scab, brown rot, etc.) a number of new pest control problems have arisen in the last few years. Some concern well known pests that have reached major pest status due to specific circumstances. Such special conditions may be attributed to the encouraged production of certain fruit varieties stemming from consumer tastes, favorable prices, changes in varietal production, monoculture, etc. or to their the unintended promotion through the use of certain cultivation or plant protection measures (man-made pests, e.g. spider mites, gall mites, leafrollers, leaf miners, etc.).

Effective control of such problem-pests is difficult in many respects because the outbreaks of their occurrence or large populations are often due to cultural practices.

In many cases it is not sufficient to solve these problems with new pesticides or plant protection measures alone. Above all it is necessary to restore the original conditions which prevailed before the new outbreak.

A few examples may be instructive at this point:

Spider Mites in Orchards

A rapid and intense development of Metatetranychus ulmi often occurs in intensively managed orchards. The reason for this outbreak often lies in the chemically-caused reduction of natural enemies (e.g. Typhlodromus species). Their normal population densities can often be restored by discontinuing pesticide applications.

Countermeasures within the framework of integrated pest management systems consist in determining economic thresholds and applying regulative chemicals only when this level is exceeded, e.g., when more than five mite stages are registered per leaf. In many cases this method alone has made it possible to keep spider mite infestations within tolerable limits. It goes without saying that the use of agricultural chemicals that encourage spider mite attack (e.g., carbaryl) is discontinued altogether.

Gall Mites on Black Currants

A steady increase in black currant production resulted in heavy infestations by gall mites within a very short time. The situation is so acute that many berry farmers are considering discontinuing production of this crop. Investigation of the problem has unfortunately led to the conclusion that at present no really effective countermeasures are available. The use of pesticides is limited by the fact that the best time for pesticide application lies too close to harvesting and, thus, increases the danger of intolerable residues. This is even more aggravating as Austria exports most of its black currants, and importing nations have rigid controls on residues. At present, intensive efforts are being undertaken by Austria and other European countries to solve this problem. Control experiments to date incorporate cultivation measures, biological control, and resistance breeding, but a favorable solution to this problem is still wanting.

Pests of Elderberry

Agricultural production of elderberry (Sambucus niger) in Austria has increased greatly in the last few years. After successful selection of the economically best-suited strains of wild elderberry, domesticated varieties have been harvested for the last 5 years. It was originally thought that, with the exception of aphids (Aphis sambucis), no major pests were to be expected on elderberry. Within the last two years, however, stem-mining fly larvae, known previously only in various weeds, have increasingly attacked young shrubs, often with fatal results. Here is clearly a case of monoculture production giving a previously unimportant insect the opportunity to become a major pest. At present, intense efforts are being made towards finding a solution to this problem.

SOME REMARKS ON THE POSSIBILITIES FOR IMPROVEMENTS IN FORECASTING AND PROGNOSIS

As mentioned above, most European countries have a more or less well-organized forecasting and prognosis system. Research scientists are, nevertheless, constantly searching for improvements and innovations. At the present time, the seasonal occurrence of many pests is being monitored with the aid of pheromone traps. In most cases, the best time for control measures can thereby be determined. In some cases, however, it is difficult to assess the actual danger indicated by pheromone trap catches.

At present, the observation of the seasonal occurrence of codling moths in Austria is conducted almost exclusively with codlemone pheromone traps. Almost all larger orchards are equipped with such traps. Unfortunately, the confirmation of male moth flight (only males are caught in these traps) is not always conclusive of infestation time. To overcome this difficulty, the field-cage method was introduced in Austria to determine exactly the actual starting time for infestation.

Small apple trees are caged for the duration of the growing season and infested with large numbers of codling-moth larvae. Adults originating from these larvae can lay their eggs only within the confine of the cage. Because the large numbers of eggs are easily seen and counted, it is therefore not difficult to determine the exact egg-laying period and to correlate these data with catches in the pheromone traps.

It is, thus, possible to obtain exact information on the time infestation begins and to guarantee satisfactory control.

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TRANSITION IN LIVESTOCK AND FORAGE PRODUCTION

H. A. Fitzhugh [1] [2]

ABSTRACT

Research on forage based livestock production will necessarily focus on ruminant production systems. The domestic ruminants of consequence in the U.S. are cattle, sheep and goats, all of which can convert forage to highly desired food and fiber products. Over three-fourths of the feed units consumed by U.S. ruminants are from forages, including permanent pastures and rangelands, cultivated pastures, hay and silage and crop residues. Forage based ruminant production systems are often well-suited to the needs and limited resources available to small farmers. Not all forage-livestock research is appropriate to the needs of small farms; however, most small farmers will benefit from basic research leading to better understanding of biological processes and applied research to improve productivity and efficiency of forage-livestock systems. The conference, "Animal Agriculture Research to Meet Human Needs in the 21st Century," developed an agenda of priority research. Recommendations relevant to forage-livestock production and to small farm systems are summarized in this presentation. Emphasis is given to socioeconomic, as well as biological, research. An interdisciplinary systems approach is recommended for research and development of forage based livestock production components appropriate to small farm systems.

Key Words: Forage, livestock, ruminants, small farms, agricultural research priorities.

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[2] Assistance of E. A. Henderson, S. J. Zimmerman, T. C. Byerly and H. J. Hodgson is gratefully acknowledged.

INTRODUCTION

Any discussion of forage and livestock necessarily focuses on ruminant production systems. In the U.S., the domestic ruminants of consequence are cattle, sheep and goats. These species share the special ability to convert fibrous forages to highly desired food and fiber products (5, 6). Several types of forage based ruminant production systems fit well the limited resources available on small farms in the U.S. Moreover, appropriate research can improve the productivity and efficiency of these systems to the mutual benefit of small farmers and consumers of ruminant products.

Several factors have contributed in recent years to a transition in forage based livestock production. A major factor has been the sharply increased demand for grain, oilseeds, and other crops for human consumption and, potentially, for fuel production. The U.S. is the major exporter in the international grain trade with predictions that U.S. grain exports will account for 70 percent of the world trade in 1985 (20). The increased competition for grains and other concentrate feeds has caused a major shift in ruminant research priorities. As Oran Little commented during a workshop on forage fed beef (17) "...if we had such a conference 10 years ago, I assure you it would have been on how to feed all grain rations to beef cattle. Ten years later we are talking about how to feed or utilize predominately forages in producing beef." Another major factor has been the sharp increase in fossil energy and derived products, such as nitrogen fertilizer, which has inflated costs of forage and livestock production.

Consumer concern for the health effects of dietary fat levels may dampen demand for livestock products in general but could promote demand for the generally lower fat meat produced from high forage diets. The recent changes in marbling requirements for the choice beef grade will likely reduce the amount of concentrates used for finishing slaughter cattle.

Another set of concerns is directly relevant to this symposium. Approximately 52 percent of the U.S. farms are classified as small farms. Forty percent of the national agricultural land resource is on these small farms. Concerns for the efficient utilization and conservation of our agricultural land resource combined with concern for insuring a reasonable standard of living for small farm families encourage research to achieve these goals.

SMALL FARMS

Previous presentations have addressed the definition of a small farm in the U.S. context. However, it is useful to restate the basis on which livestock-forage research priorities will be addressed with respect to small farms. The USDA definition is based on three factors (18): (i) family net income from all sources (farm and nonfarm) is below the median nonmetropolitan income of the state; (ii) family is dependent on farming for a significant, though not necessarily a majority, portion of its income; and (iii) family members provide most of the labor and management. The generally applied criterion for defining small farms derived from these factors is gross annual farm sales less than $20,000 and/or family income below the nonmetropolitan median income.

National, cultural, geographical and ecological factors contribute to the considerable variation among regions in farm size and productivity (table 1). Of total farms in each region in 1970, the percentages which were in the small classification were: Northeast, 54; North Central, 52; South, 57; West, 43. Approximately one-third of the farms in the Northeast, South and West regions and one-sixth in the North Central region had annual sales of less than $2,500.

Most small farm families derive the majority of their income from off-farm employment and other sources (9). Thus, classification of small farmers with respect to availability of labor and management inputs to forage based livestock systems is useful. Five classifications were used in the Allegheny Highlands Project (1):

1. Full-time, no outside income
2. Full-time, outside income
3. Part-time, farming major activity
4. Part-time, farming minor activity
5. Retired, no off-farm employment but regular retirement income.

Members of groups 1 and 2 could presumably devote their full attention to farming activities. The types of off-farm employment (e.g., school bus driver) in group 3 still allowed primary attention to the farming operation; similarly, retirees could attend to the details of the farm, although their physical capacities could be a limiting factor. Members of group 4, however, necessarily placed secondary emphasis on farming activities, which was reflected in the poorer performance of their livestock herds (e.g., lowest calving percentage, highest calf mortality, lowest average weaning weight).

A recent analysis (12) noted the steady decline in numbers of U.S. farms since 1935. They predict a further decline from about 2.5 million in 1980 to 1.8 million farms in 2000 with almost all the decline in the small farm category. They suggest that most small farms will be operated as a sideline with the category of part-time farmers including the retired and hobby farmers. These part-time farmers will specialize in activities that do not require much labor, with beef cattle (not dairy cattle) given as an example of this type of activity.

FORAGE

Forage refers to the vegetative portions of a wide variety of plants, including about 100 species of grass and legumes cultivated in the U.S.; grasses, forbs and browse from permanent pastures, rangelands and the forest understory;

Table 1. Farm Size and Agricultural Land Use by Regions of United States

	All farms				Farms with sales over $2,500			
Item	North-east	North Central	South	West	North-east	North Central	South	West
No. Farms, thousands	149	1,028	1,015	286	104	874	683	203
Av. Farm Size, ha	68	144	125	461	83	161	170	540
Agricultural Land, million ha	10	148	127	132	9	141	116	110
% Harvested Cropland[1]	45	51	26	13	48	53	27	16
% Pasture, Total[1]	24	33	58	78	23	31	57	74
Cropland	(12)	(7)	(12)	(2)	(11)	(7)	(11)	(2)
Woodland	(5)	(3)	(7)	(5)	(5)	(3)	(6)	(2)
Pasture-range	(7)	(23)	(39)	(71)	(7)	(21)	(40)	(70)
% Other, Total[1]	32	16	16	9	30	15	15	9
Cropland	(5)	(8)	(5)	(6)	(4)	(8)	(5)	(6)
Woodland	(20)	(3)	(8)	(1)	(19)	(3)	(7)	(1)
Non-cropped	(7)	(5)	(3)	(2)	(7)	(4)	(3)	(2)

[1] Expressed as percent of agricultural land in region.

Source: 1978 Census of Agriculture. U.S. Bureau of Census.

hay and silage crops; and the residues of food and fiber crops (7). Forage is generally grown on land not suited for food crops; there is 28 percent more permanent pasture and rangeland than cropland in the U.S. (8). Increased demand for food crops will likely reduce the amount of cropland currently devoted to pasture, silage and hay production (table 1); however, increased quantities of residues from food crops will be available. Most of these residues will remain unharvested to promote soil fertility and prevent erosion (table 2).

Table 2. Total and Usable Residues for Selected Major Crops in United States (11)

Crop	Total residue	Usable residue [1]
Corn	171	37.1
Small grains	135	34.6
Sorghum	21	1.5
Rice	9	5.5
Sugarcane	5	.6
Cotton	4	-
Soybeans	68	-

[1] Amount in excess of that needed to limit erosion and in sufficient quantity to justify harvest.

RUMINANTS

The U.S. population of domestic ruminants consists of 111 million cattle (including 15 million dairy cows and heifers), 12.5 million sheep and 1.3 million goats. Considerable variation exists among regions in average numbers per farm for each class of ruminants (table 3). The majority of the farms in each region incorporated some type of cattle activity. These non-mutually exclusive types included beef cows, dairy cows, heifers, steers and bulls. The percentages of total farms in each region with beef and dairy cows, respectively, were: Northeast, 23 and 34; North Central, 36 and 16; South, 52 and 9; West, 38 and 12.

Of the total farms in U.S. classified as livestock, dairy or general in 1978, 43 percent were small farms.

The majority of the feed units consumed by ruminants is derived from forage; whereas, nonruminants primarily consume concentrates, such as grains and oilseeds (table 4). Elimination of grain feeding to U.S. livestock would reduce the annual production of animal protein from 5.4 to 2.9 million tons; commercial swine and poultry production would virtually cease and annual offtake of beef and milk would decline 24 and 28 percent, respectively (13). The concentrates consumed by ruminants tend to be those used as supplements to the forage based diets of

Table 3. Percentage of Farms with Livestock and Average Numbers of Livestock per Farm by Region of United States

Item	All farms in region				Farms with sales over $2,500			
	Northeast	North Central	South	West	Northeast	North Central	South	West
Total no. farms, thousands	149	1,028	1,015	286	104	874	683	203
% of farms with cattle	60	57	62	52	63	59	62	53
Av. no. cattle per farm [1]	47	74	58	141	61	83	78	191
Av. no. beef cows per farm [1]	9	33	30	66	10	37	40	87
Av. no. dairy cows per farm [1]	38	29	24	47	44	31	33	62
% of farms with sheep	5	5	2	8	4	5	2	7
Av. no. sheep per farm [1]	25	57	153	288	25	63	200	393
% of farms with goats	2	.6	1	2	1	.3	1	1
Av. no. goats per farm [1]	7	7	83	32	10	10	167	15
% of farms with horses, ponies	22	15	19	32	18	14	18	30
Av. no. horses per farm [1]	6	4	4	7	5	4	4	7

[1] Averages are computed, for example, as total cattle/no. of farms with cattle in region.

Source: 1978 Census of Agriculture. U.S. Bureau of the Census.

high producing dairy cows and cattle being fed for slaughter.

Neither of these types of ruminant production is expected to be of particular consequence on small farms. Instead, the land, labor, management and capital resources of small farmers are generally better suited to maintenance of breeding herds from which young stock are slaughtered for family use or sold -- sometimes for slaughter but, more often, for additional feeding.

Table 4. Sources of Feed Units for United States Livestock (8) [1]

Type of Livestock	Source of feed, million MT			Percent Forage
	Concentrate	Forage	Total	
Dairy cattle	24	42	66	64
Beef cattle	33	172	205	84
Sheep and goats	1	6	7	86
All ruminants	58	220	278	79
All nonruminants	100	20	120	17
Percent by ruminants	37	92	70	

[1] A feed unit is nutritional equivalent of .454 kg corn.

Exceptions to this general type of production system do occur. For example, there are approximately 500 herds of dairy goats on small farms in northern Arkansas, southern Missouri and eastern Oklahoma.

Four types of dairy goat operations have been described (21):

- Homesteader with 5 to 10 does producing milk and meat for family use.
- Hobbyist with 15 to 20 does kept primarily for pleasure and competition in shows.
- Semi-commercial herds of 15 to 60 does marketing milk through pigs, calves and breeding stock.
- Commercial herds of varying size marketing milk for human consumption and sales of breeding stock.

Small farmers may be more inclined than large farmers to keep dairy goats (10) because family members supply labor and goat milk is usually consumed on farm or sold direct to consumer rather than to commercial processing plants.

RESEARCH PRIORITIES FOR FORAGE BASED LIVESTOCK PRODUCTION SYSTEMS

Not all research to improve productivity of forage-based livestock systems will benefit small farmers. However, a general basis for classifying agricultural research in relation to farm size has been suggested (18):

1. Small Farm -- research on problems unique to small farms taking into account the generally limited resources available.

2. Not Size Specific -- research on problems relevant to all types of farming operations; most basic agricultural research is in this category.

3. Large Farm -- research on problems unique to large farms such as capital intensive technology development.

The recent conference, Animal Agriculture Research to Meet Human Needs in the 21st Century, developed an agenda of research priorities for U.S. animal agriculture (14). This agenda included priorities for basic and applied research in all facets of animal agriculture -- animal nutrition, physiology, genetics and health; feed production; resources and environment; food processing, acceptability and safety; human nutrition; and public policy. Substantial attention was given to research to improve productivity and efficiency of forage based livestock systems. Many of the research recommendations developed by this conference are appropriate to small farms.

Forage Research

Priorities developed for basic and applied research efforts to improve forage (chapters 8 and 10 of reference 14) included:

1. Increase utilization efficiency of ligno-cellulosic plant materials, which are the most abundent organic compounds in the world. Ruminants utilize them, but with low efficiency. Greatest opportunities for improving utilization efficiency include:

   -- Develop basic information on biochemistry of synthesis and degradation of ligno-cellulosic forage materials. Basic research may lead to efficient means of unlocking the ligno-cellulosic bonds.

   -- Improve procedures for measuring forage quality. Rapid, inexpensive, accurate and precise procedures for measuring forage quality are needed to facilitate forage breeding and management and provide information needed to balance livestock diets.

   -- Improve harvesting, storing and processing technologies to preserve and enhance feed quality. Losses of nutrient quality during and after harvest are substantial (table 5). The small farm with its already limited-resource base can hardly afford these losses; however, technologies to prevent them must be appropriate to the small farmer's situation.

   -- Enhance forage yield and quality through breeding. Genetic improvement of quality will involve improved digestibility of plant cellulose, decreased lignification, increased palatability and elimination of antiquality factors. Legumes by fixing atmospheric nitrogen can sharply reduce requirements for commercial nitrogen when grown in mixed culture with grass species for pasture, hay and silage.

   -- Optimize forage yield and quality through improved management. Particular attention should be given to management systems which integrate forage quantity and quality (often on seasonal basis) to needs of animals of differing classes, ages and production levels. These management strategies should emphasize sustainable yields of forage compatible with resource recycling and minimal energy inputs.

Table 5. Average Dry Matter Losses for Dry Hay, Low-Moisture Hay Silage and Corn Silage (15)

	Dry matter losses, %			
Practice	Harvesting	Storage	Feeding	Total
Dry hay, baled				
Field cured, rain damage	33	4	8	45
Field cured, no rain	17	4	8	29
Low moisture hay silage	5-8	2-6	5	15
Corn silage	1-3	7-14	5	15

Successful realization and implementation of these priority research topics would have major impact on potential productivity of forage-livestock systems (table 6). Even hundred-fold improvements in meat and milk yields per hectare are within the realm of possibility (2).

While these potentials for forage production are real, many small farmers will be producing forage on marginal lands. Strategies are needed for optimizing forage production on marginal lands and/or in combination with other activities, such as double cropping forage with cash crops (10) and forage with timber (4).

Table 6. Potentials for Annual Forage and Cattle Productivity in Humid, Temperate Climate (12)

Forage production technology	Forage productivity		Cattle productivity	
	Dry matter	Digestibility	Weight gain	Milk
	MT/ha	%	- MT/ha -	
Harvested forage				
Average management	8	55	.19	3.6
Improved fertility	10	55	.24	4.5
Improved variety and pest control	12	57	.44	8.1
Timely harvest	14	60	.86	12.8
Reduced harvest loss	15	65	1.56	20.7
Permanent grazing land				
Average management	2	52	.02	.5
Improved fertility	4	54	.08	1.6
Renovation, interseeding with legumes	5	57	.17	3.5
Improved grazing management	6	60	.37	5.5

Livestock Research

Research imperatives were defined for animal nutrition and digestive physiology, animal genetics and reproduction, and animal health (chapters 5, 6, and 7 of reference 14).

Nutrition and Digestive Physiology

1. Cellular processes associated with protein synthesis. Three areas where basic knowledge is needed: (i) biological control systems limiting efficiency of protein production, (ii) regulation of adipocyte number and fat deposition properties, and (iii) structure of body cells.

   Underlying these research emphases was the belief that protein, rather than fat, synthesis will have major priority in animal production.

2. Interactions among alimentary tract microbial systems, digestive processes and the host animal. Research is needed to improve and better utilize the synergistic processes of microbial fermentation in the rumen and digestion, and metabolism by the ruminant.

3. Conservation of nutrients. Failure to provide balanced diets which meet animal requirements at different stages of development and levels of production is wasteful. The limiting nutrient(s) sets the ceiling on efficient utilization of the diet. This research area is especially relevant to forage based systems where there may be limited variety in types of feed available so that nutrient deficiencies in minerals or, seasonally, in energy and protein are common.

4. Control of feed intake. Feed intake is a major determinant of animal performance. Low digestibility of many forage rations which reduce daily intakes of dry matter below requirements for top performance is a major constraint.

5. Integrated nutrient management. Research is needed to determine replacement values among nutrient resources to provide basis for developing cost-effective nutritional regimes.

6. Nutritional characterization of feedstuffs. Information on bio-availability of nutrients and harmful effects of antiquality factors and toxins is lacking, especially for forage residues, industrial by-products and nonconventional feedstuffs.

Genetics and Reproduction

1. Reproductive inefficiency is a major limiting constraint to animal production. Basic research is needed to understand and modify the physiological processes of estrus, ovulation, fertilization, embryo development, parturition and perinatal survival. This understanding will support development of integrated reproductive management programs tailored to needs of specific production systems, such as those for small farms.

   Major breakthroughs in such technologies as ova harvest, external fertilization, embryo preservation and cloning may not have direct application to small farms situations, but indirect benefits will accrue from increased rates of genetic improvement in the general U.S. animal population. Other technologies, such as induced twinning and sex control, could be directly implemented to improve productivity of small farm herds.

2. Knowledge is needed about the genetic basis for protein synthesis, as mediated by enzymes, hormones and intracellular processes. This knowledge can lead to selection and breeding of farm animals that produce protein more efficiently and deposit fat in desired balance.

3. Strategies for germ plasm improvement and utilization require clarification of objectives (largely dependent on production goals) and better means for measuring genetic merit. Genetic improvement of farm animals is a long term process; if the goals toward which selection is divided prove inappropriate (because of changes in the production environment or change in market requirements), much time and effort is lost.

Some important traits (such as efficiency of protein synthesis for mark growth on lactation) can only be measured indirectly, if at all. Direct measurement of the underlying physiological processes would improve selection efficiency, especially for sex limited traits such as milk production.

Genotype should be matched to the production environment. Genetic choices can be made at several levels: among species, among breeds, among individuals. Examples of choices relevant to small farms include: dairy goats vs. dairy cows; hair sheep vs. wool sheep; large, fast growing cattle vs. small, early maturing cattle.

The limited genetic variation available within herds on small farms is not well suited to effective on-farm selection programs. However, genetic improvement can be realized through use of superior sires developed elsewhere and by crossbreeding for complementarity and heterosis. New breeds combining favorable attributes of several breeds are being developed; some should be designed to match the special needs of small farm production environments.

Genetic engineering offers major opportunities for reducing costs and increasing efficiency of food animal production. Recombinant DNA technology can lead to low cost sources of pharmaceuticals to improve animal health and to stimulate the physiological processes underlying production traits. Breakthroughs in mammalism gene transfer, perhaps combined with cloning, can lead to rapid development of genotypes tailored to specific production environments.

Health

1. Development of integrated animal health systems will require interdisciplinary research efforts to identify and quantify factors and interactions causing health problems. This knowledge must then be applied to develop and deliver practical programs for control of production diseases. Research activities should include on-farm monitoring of health problems, use of computer stimulation models and development of national disease information systems (including animal identification and diagnostic procedures) needed for effective control of major diseases, such as brucellosis, which limit productivity and profitability.

2. Identify and enhance disease resistance through such research based techologices as use of recombinant DNA to develop vaccines, gave transfer to produce immunity to specific disease agents and stimulation of the animal's immune systems during critical performance periods (e.g., neonatal and environmental stress situations).

3. Improve knowledge of the effects and mode of action of the broad spectrum of chemicals (contaminants, additives, toxins and drugs) to which farm animals are exposed. This research will lead to more effective regulatory decisions, enhance the effectiveness of drugs and limit the harmful effects of chemicals and toxins (mycotoxins, plant toxins).

The forest-livestock research priorities developed by the "Animal Agriculture Research" conference are generally similar to those developed by a USDA research work group for the southern region (19), namely:

-- Improve forage quality and quantity through introduction of pasture legumes; control of weeds and poisonous plants; implementation of more efficient cultural and management practices and improved harvesting, storing and processing techniques.

-- Develop methods to rapidly and precisely predict nutritional value of forage.

-- Evaluate and neutralize disease, toxicological, parasitic and stress problems that reduce efficiency of forage based livestock production systems.

-- Define and evaluate major interactions between animal genotype and production environment.

-- Develop profitable, efficient systems for finishing slaughter cattle on high forage rations.

-- Define alternative or multiple land use options and compare these to use of resources for forage-livestock production.

The implementation plan for these USDA priorities currently involves eleven research locations in the southern region. One of these is the South Central Small Farms Research Center at Booneville, Arkansas, where research efforts will be directed toward improving the contributions of beef cattle, sheep, and goats and other livestock enterprises to the small farm business.

Economics and Information

Agricultural producers are accustomed, if not always able, to cope with the adverse effects of weather and other vagaries over which they have no control. The past decade has seen many unexpected events which adversely affected the profitability of both large and small operations. These have included livestock price controls, regulations on production practices, increase in energy costs and rise in interest rates.

Priority was given by the Animal Agriculture Research Conference to research to improve economic planning and dampen the adverse effects of unexpected events (chapter 9 of reference 14). This research included development of forecasting methods and contingency plans, examination of market coordinating mechanisms and improvement of marketing services available to livestock producers.

Unfortunately, small farmers frequently lack access to and the ability to utilize information, credit and marketing services which already exist. Few economic strategies have specifically addressed the special constraints faced by small farmers: limited credit, poor cash flow, labor availability, limited market options (10). New approaches -- more development than research oriented --are needed to assist small farmers. One such approach is the Rural Ventures pilot project at Princeton, Minnesota where Control Data Corporation is supporting small farmers with financial and technical assistance and, most importantly, access to modern information and management support technology. This technology includes computer aided instruction, videotapes, business record programs and, potentially, networks of small farmers coordinating purchases and sales in order to achieve the economies available to large operations.

Interdisciplinary Systems Approach

Improvements to forage based livestock components appropriate for small farms require an interdisciplinary systems approach to research and extension. In many ways small farms are more complex systems than are large farms. Certainly operators of large farms must be oriented to the "bottom line" while many small farmers remain in agriculture for both financial and nonfinancial reasons.

The limited resource base and special constraints faced by small farmers must be identified and better characterized to ensure development of appropriate research priorities and procedures. Classifications based on farm sales (and/or family income) and source of labor are adequate for general descriptive purposes. However, design of research to improve forage livestock -- or any other component -- requires more detailed agricultural, ecological, economic and sociological characterization. Computer models should prove useful in this characterization stage, in preliminary screening of research alternatives and in initial evaluation of proposed interventions (3, 16). Ultimately, research findings should be evaluated on small farms to demonstrate that they fit the social, economic and environmental characteristics of small farms and small farmers.

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DEVELOPING A MANAGEMENT SYSTEM FOR A SMALL BEEF FARM

Danny G. Fox 1/

ABSTRACT

Small beef farms have some disadvantages due to the difficulty of having enough animal numbers to competitively dilute fixed costs, time constraints and difficulty in marketing small numbers. Their feed resources are often higher cost, because of not having crop residues or farm equipment available compared to full time farms. However, they can often offset their disadvantages by not being dependent on the farm for a major source of income for family living, using it as an investment and primarily as a place to live. They may often be in a better position to optimize management practices because of personal interest, small numbers and opportunity to develop specialty markets. Also they are more insulated from wide price fluctuations, because of outside income and their small size. They often can be more flexible, taking advantage of any lower cost or by-product feeds and varying their marketing program as prices change. Their best chance to compete is to maximize their advantages, including not being dependent on it for family living costs; ability to survive wide price fluctuations; being flexible and developing specialty marketing opportunities.

Keywords: Small beef farms, small scale farms, beef production, small farms.

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INTRODUCTION

Production of feeder calves in the U.S. is typically a small scale enterprise. About 40 percent of the beef cows in the U.S. are in herds of less than 50 cows and 60 percent are in herds of less than 100 cows; about 90 percent of the people who own beef cows have less than 100 head. Thus the typical beef herd is small and is supplementary to some other enterprise. Feed resources used are those that have little alternative use such as crop residues, poorer cropland, untillable land or rangeland that cannot produce crops other than grass due to limitations in rainfall or weather patterns. In small herds, surplus labor is used to operate the beef herd, and much of the work can be planned around cropping or off-the-farm work schedules. As a result of these factors, it is often the only alternative for utilizing available land and forage resources, resulting in a large proportion of herds being kept at relatively low market prices for feeder cattle and profit margins. Profits are usually considered to be those returns above "out of pocket" costs for fuel, repairs, fencing, purchased minerals and supplies, etc. Whatever is left above those costs are considered returns for pasture or crop residues or other feed resources that have no alternative market. Many will keep the herd as long as "out of pocket" costs are covered. In most small herds, labor, land, or interest on investment are not considered "out of pocket" costs.

A high proportion of small herds are kept on full time family farms, where part of the necessary machinery and equipment is available for producing and harvesting the winter feed. The calves are usually weaned at about 6-7 months of age, and are assembled into larger groups and shipped to feedlots in areas where feed grains are abundant. Cattle feeding is a large scale industry, with about 70 percent being fed in lots with over 1,000 head capacity. Profit margins are small per head, with the primary objective being to use feeder cattle as a means of marketing the feed grain crop to a better advantage. Because of the intense competition and small potential profits per head, individual feedlots must use large numbers, all available technology, and must operate efficiently to compete and survive.

This general nature of the beef cattle industry poses some unique problems for the small beef farm. They must compete within an intensely competitive industry, where profit margins per head are small. This paper will outline some of their unique management problems, followed by a discussion of considerations that must be taken into account for the small farm to be viable.

UNIQUE MANAGEMENT PROBLEMS OF A SMALL FARM

The term "small farm" implies that most of the income is earned off the farm. This in turn implies the following.

1. Either One Or Both Of The Husband And Wife Will Not Be On The Farm For Part Or All Of The Day for most days. This presents difficulties especially during calving, breeding and marketing; harvesting, machinery breakdowns and obtaining parts and supplies; treating injured or sick animals; and animals getting through fences.

2. They May Have To Commute for one-half to one hour to reach work. The small farm will likely be in a rural area, and available work off the farm will likely be in a town or city. This further shortens the time available to operate the farm. In most cases only about one hour is available per day plus weekends, holidays and vacations to do the work.

3. The Farm Is Likely To Be Low In Productivity, with shallow, acid, low fertility and poorly drained or hillside soils. Most of the more productive land trades hands between full time farmers or is leased to them by former farmers or their relatives. The only land available, or the only land affordable, may be this type of resource. Therefore, forage production and grazing often is their only alternative agricultural enterprise. For this reason, a high proportion sell their calves at weaning when few or no crops are grown and purchased concentrates are considerably greater in cost than cost of producing them.

4. All Equipment Purchased Will Be Used Only For The Beef Cattle Enterprise. On the full time farm much of the most expensive equipment needed will be spread over the major enterprise, with little or no cost of these items being charged to the beef cattle. Thus much of the "affordable" equipment will be small and used, requiring more time to accomplish tasks and more repairs. Yet the part-time farmer has limited time available, because of the demands of his off-the-farm work. Thus large equipment is often justifiable but not affordable.

Thus any management system designed for the small farm must take these factors into account; limited time and not being physically on the farm much of the time; limited soil resources; and costs of equipment relative to size of enterprises.

DEVELOPING A MANAGEMENT SYSTEM FOR A SMALL BEEF FARM

In general, the small farmer must use the same technology as larger farmers in order to compete economically (3). He should use the local extension service and government programs (SCS, ASCS) as much as large farmers. In addition, he must organize his farm in such a way that he can deal with the problems described previously. In outlining development of a management system for a small farm, it will be assumed that supplemental income is earned off the farm. This represents most situations in the U.S. with few using it as a place to earn a subsistence living. Research is underway at Cornell to develop management systems for the small beef farm, including land, facilities, cattle and investment management. Results to date plus field experience suggest the following.

1. The Small Beef Farm Should Be Considered Primarily As The Choice Of A Place To Live and a way of life with the beef cattle being used to keep the land open, provide a market for available forage, as a hedge against inflation, and as a secondary source of income to build equity. A regular source of off-the-farm income is usually used to meet daily living expenses and many cash farm expenses. A survey of beef cow-calf producers in six Northeastern states (4) indicated that the major reason for selecting a beef cattle enterprise was to utilize existing land and buildings. Increasing income was second, with keeping the land open being third.

It would be extremely difficult to compete and survive economically by purchasing a typical small farm and developing it for beef cattle with the intent of making a family living from it, especially when mortage and operating loan payments must be met. However, with supplemental income, it can be a means and may be one of the few alternatives for meeting many of the objectives of the part-time farm family (small scale farming to meet personal desires; to relieve job related stress; for rural living; building equity in an agricultural enterprise through use of surplus labor, tax benefits and forced savings; and to develop a retirement project).

2. Capital Investments Must Be Made Carefully.

A. Fencing. Good, dependable boundary fences are essential because of the absence of the operator much of the time. Yet fencing costs must be minimized. It may be desirable through heavily wooded areas to use woven wire fence fastened to trees to prevent cattle from getting out when trees or limbs fall over the fence. In brushy areas or even in heavily weed loaded areas, the low cost high tensile spring tension electric fence with the New Zealand high voltage charger has been very satisfactory for perimeter fence. It can be as low or lower in cost than barbed wire, and may provide less maintenance problems and some control of predators and trespassers.

B. Facilities. In the Cornell beef research and demonstration projects, beef cows are kept outside year around to minimize facility and labor costs, and to reduce health problems. The wintering areas are organized to allow access to trees, and a stream that flows year around when possible. Feeding is on the ground or in bunks in an area easily accessible even during severe conditions (snow or rain and mud). A calving area is reserved in a protected area as near the road or house as possible, with cows being turned into the area just ahead of calving. Animals are kept out of this area in the fall to permit a heavy sod to develop. Labor and health problems have been greatly reduced since this system was implemented. A high priority is to develop handling facilities so that key management practices can be accomplished with a minimum of time, effort and frustration. The old dairy barn was renovated to contain handling facilities and a small, low labor feedlot for finishing the calves. Total barn renovation cost was less than $1,500.

C. Pasture Improvement. Whether or not to make capital improvements to improve the pastures is a difficult decision. In studies at Cornell, daily gains of calves nursing cows grazed on unimproved or pasture improved with lime, fertilizer and birdsfoot trefoil plus brome or bromegrass alone were similar. However, acres required per cow-calf unit for 5 months of grazing were reduced from 6-7 acres to 2-2 1/2 acres. But the cost of improvement was over $200 per acre. Preliminary analysis indicate that pasture improvement will be profitable only if maximum use of the forage is made. This includes stocking to maximum carrying capacity and rotational grazing, and managing to extend the grazing season. In many cases the part-time farmer may have excess land available relative to the number of head he can care for. A high proportion of herds on part-time farms contain only 10-25 breeding animals, regardless of the size of land base because of limitations in labor. However, if the land is not renovated, it should still be "improved" by clipping at least once in midsummer and rotationally grazed. The grazing season needs to be as long as possible, to minimize labor and higher cost harvested feed use and to maximize calf weaning weights.

D. "Sunk" Capital Investments. Many small farms are purchased and developed as an investment, with the intent of selling it at some later date. If the farm is sold, a typical small farmer may be able to recover a return for his labor in land clearing, and improving the appearance of his farm. However, he may recover only part of the capital invested in pasture improvement, fencing, and facilities. A marginal land resource farm may have fewer buyers than one on a good soil resource. Further, the objectives of the new buyer may be different, and they may not need or are not willing to pay for many of the improvements.

E. Source Of Funds For Capital Improvements. The survey of Schwab and Garst (4) indicated only 32 percent of small beef farmers used borrowed capital. Because of the poor cash flow and fluctuations in market prices, borrowed capital is used typically for operating expenses which can be paid for when the cattle are sold. Capital investments are made if they can be paid for by outside income, tax returns or only in years when income from sale of cattle exceeds operating costs or they have been covered by other sources of income.

F. Machinery Costs Must Be Minimized. This usually means careful shopping for used equipment unless tax benefits offset the small numbers of cattle that must cover costs. Small equipment is usually lower in cost. However, if good buys can be made on larger equipment, it can be beneficial because of the limited time available.

CATTLE MANAGEMENT PRACTICES

Part-time farmers must organize their program so that it is time efficient. This means that they should calendarize their management program, so that key practices can be planned around vacations and slack times for the off-the-farm job. Tables 1 and 2 show the economic impact of various management practices. Most do not implement all of the technology available because of constraints in time, facilities, capital, or conflicts with goals. Accomplishing many of those high priority practices listed in tables 1 and 2 however may also reduce labor and frustration while improving returns. Key management practices are as follows.

1. Plan The Calving Season so that cattle are grazing during times of peak nutrient requirements for rebreeding, yet at a time when weather is not as severe if no one will be available to watch cows at calving. Weaning weights and rebreeding will usually be synchronized with least cost feeding if calves are born 30 to 45 days before the spring grazing season starts. The first limiting factor in returns with beef cows is the percent calf crop weaned. Saving calves involves close attention at calving and early detection and treatment of sick calves (3).

2. Have A Short Calving Season. Low weaning weights are often due to late calves. They do not have equal opportunity, as weaning in the fall is usually on one day. Also it is difficult to intensively observe a herd for calving problems for more than 4-6 weeks, especially due to demands of the off-the-farm job. A further complication is that late calving cows will not have as much time before the breeding season to recycle. Proper nutrition of the first and second calf heifers is very critical to get them rebred on time. The most

Table 1. Priorities for Management - Cow-Calf Herd[1]

	Careless	Careful	Amt./ 25 cows	$/25 cows
Calf crop/12 months	80%	92%	1200 lb	720[a]
Length of calving season	90 days	45 days	675 lb	405[b]
Selection	None	35#/calf	700 lb	420[c]
Crossbreeding	None	48#/calf	960 lb	576[d]
Cattle type	Small frame	Avg. +	5¢/lb	400
Castration	None	Does	10¢/lb	400[e]
Implanting	None	Does	25 lb/calf	300[f]
Worming	None	Does	40 lb/calf	480[g]
Winter feed cost and length of grazing season	5 mo. grazing	6 1/2 mo. grazing, minimum winter feed cost	$50/cow less	1250
Non-feed cost	$100/cow	$50/cow	$50/cow less	1250
Marketing	No plan	Graded sale	10¢/lb	800

Assumptions based on additional value marketed by careful producer, @ 60¢/lb for calves. [a]20 vs. 23 - 400 lb calves; [b]45 days x 1.5 lb/day on 1/2 of calves; [c]35 lb on 20 calves; [d]48 lb on 20 calves; [e]10 males at 400 lb; [f]20 calves x 25 lb; [g]only if calves need worming.

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[1] Fact Sheet 4000, Cornell Beef Production Manual.

Table 2. Priorities for Management - Growing-Finishing Cattle[1]

	Careless	Careful	Amount	Value/600 lb gain
Feeder quality, health	Poor	Good	$3/cwt.	18
Environment	High stress	Minimum stress	$5/cwt. gain	30
Proper implanting	No	Yes	$3/cwt. gain	18
Rumensin	No	Yes	$2/cwt. gain	12
Balanced ration	No	Yes	$6/cwt. gain	36
Feed intake	Avg.	+ 10%	$2/cwt. gain	12
Optimum feeding system	No	Yes	$3/cwt. gain	18
Carcass quality grade	Good	Choice	$4/cwt.	24
Carcass yield grade	4	3	$4/cwt.	24
Carcass weight	Under 600 lb	Over 600 lb	$2/cwt	12

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[1] Fact Sheet 5050, Cornell Beef Production Manual.

critical factor is to have all cows in good condition when breeding starts. Cows that go into the winter in good condition have lower maintenance requirements in the winter and will have a better chance of having the energy available for rapid recycling following calving.

3. Maximize Weight Sold Per Cow Maintained. Because of limitations on animal numbers, a small farmer has to dilute relatively high fixed costs. The following are guidelines.

A. Keep Cows of Medium To Large Size. Although research has shown differences in overall efficiency are small between mature sizes of cows (1), small farmers are limited by the number of head they can care for and, thus, must sell as much weight as possible per cow to dilute fixed costs. Larger cows tend to wean larger calves, and medium to large frame feeder calves are in greatest demand. However, they should attempt to select for those medium size cows that wean heavy calves, and cull cows that do not breed back quickly and/or do not wean above average weaning weight calves.

B. Purchase Bulls With Known Performance. Use of artificial insemination is one way to improve calf weaning weights. However, it is very difficult to manage on a part-time farm, because of the logistics involved in heat checking and breeding and having someone present to assist the inseminator. One system that will work is to synchronize breeding for weekend insemination. Cows can be held in drylot during this period for ease of handling and breeding. For most small part-time herds, however, the best approach is to purchase a bull with above average performance from a herd with performance data or from a state sponsored performance tested bull sale. A young bull will service the typical small herd, and the net breeding cost will be minimal because of the increase in weight of the bull by the time they need to sell him.

C. Make Sure An Abundant Supply Of Forage Is Available Throughout The Growing Season For The Calves. Figure 1 shows the impact of supplemental feed on growth of the nursing calf (2). Calves become increasing dependent on the pasture after 60 days of age. Although the Cornell research has shown unimproved pastures to give equivalent calf gains, they often are not productive through the midsummer months. Creep grazing or having some improved pasture for this period are possibilities.

D. Consider Implanting the calves not to be used as breeding animals at 90 days with a growth stimulant. This practice usually improves weaning weights 20-30 lb.

4. Herd Wintering Costs Must Be Minimized. Herds on full time farms usually can be wintered in part from grazing crop residues. This alternative is usually not available to the small farmer, which can make his wintering costs

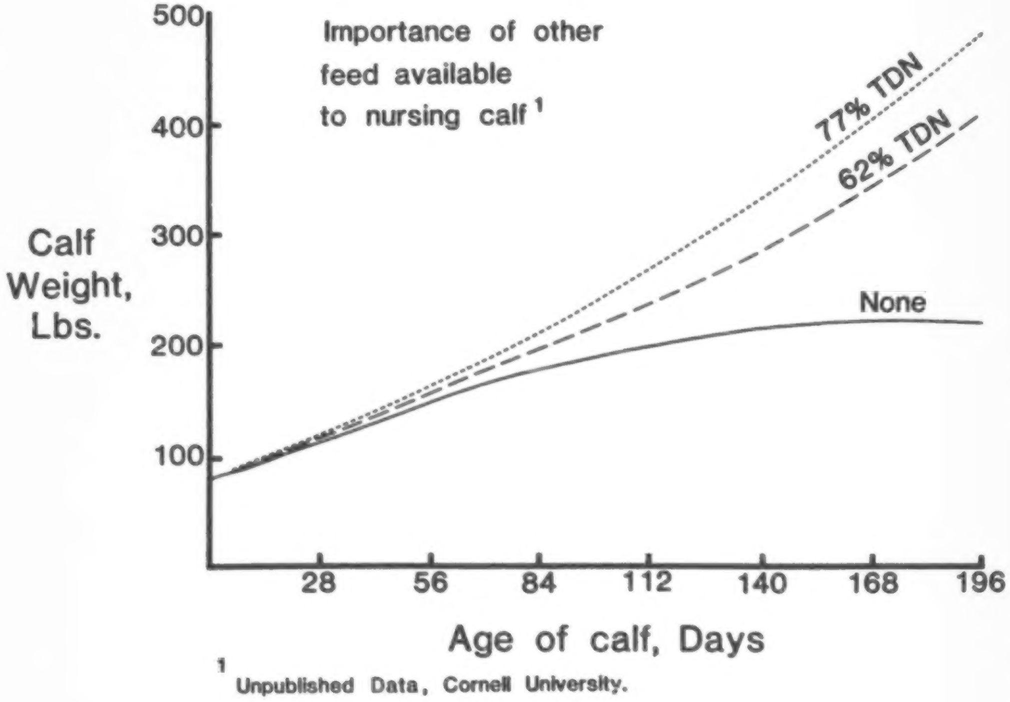

Figure 1. Impact of Supplemental Feed on Growth of the Nursing Calf

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relatively higher. The grazing season should be as long as possible to be competitive. Secondly, the small farmer must be cautious in overspending for equipment to harvest winter feed, because of his lower volume to dilute these costs.

5. Have An Above Average Marketing Plan. Small farms must try to overcome their smaller numbers and higher fixed costs by selling their product for a higher price. A few feeders for someone wanting to raise their own meat, or freezer beef produced to satisfy a specialty demand (low fat content; breed biases; biases on use of feed additives or growth stimulants; being able to buy their beef direct from the farmer they know) are typical approaches.

6. A Small Farm Should Be as Flexible As Possible. Most large farms are locked into feed production and feeding systems that cannot be changed very easily. It is often easier for small farmers to change their program as costs and market conditions change. The marketing period for feeder calves can be extended by carrying them beyond weaning on home grown forages. They can then be sold as yearling feeder cattle when market prices are favorable, or then feed them to normal slaughter weights if high energy feeds are available. They can vary their feeding program to take advantage of low cost by-product feeds that might be available in their area.

If the cattle are finished for slaughter, however, the small farmer must be careful to use the best management practices possible (table 2). They should be in contact with their local extension service for help in this regard. Large feedlots are efficient, having the advantages of a large volume to dilute fixed costs and to attract buyers for finished cattle, and can justify consultants to help them. However, they are generally committed to high grain feeding programs. By-product or residue feeds are difficult for them to use. Further, most of the information that their consultants provide is available to all through the local extension service at no cost.

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USE OF UNDER-UTILIZED AND BY-PRODUCT FEEDS FOR BREEDING CATTLE AND SHEEP

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ABSTRACT

The utilization of by-product feedstuffs for breeding cattle and sheep has been investigated for many years. Examples of some of the more common feeds are bakery wastes, cull fruits and vegetables, brewery and distillery by-products, animal manures and cellulosic materials such as cereal straws, corn and milo stovers and hulls. Many of the by-products are low in protein (3-6%) and energy (45-55% TDN), while others are quite high (20-31% protein and 48-73% TDN). The objective, then, is to maximize and optimize the incorporation of these feedstuffs into livestock diets when economically feasible. Naturally, the moisture, and nutrient content, pesticide contamination and palatability of these feeds vary considerably and must be recognized when formulating diets to achieve maximum animal performance. Chemical analyses on each batch of the feedstuff may be needed to properly formulate balanced diets. The economics of including by-product feeds in these diets should be determined prior to their use and cannot be overemphasized. State and federal regulations may prohibit the use of some of these feedstuffs in certain diets and these should be identified before feeding.

Keywords: By-product feeds, under-utilized feeds, breeding cattle, breeding sheep, nutrient content, supplementation, animal performance, small farms.

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Feed costs are the single largest expense in beef and sheep production. Therefore, anything that might reduce these costs could have a major impact on the net income of the production system. Underutilized and by-product feeds can supply much of the daily nutrient intake of cattle and sheep when they are properly supplemented with protein, energy, vitamins and minerals when appropriate.

Frequently, by-product feeds are associated with cellulosic materials, i.e., feedstuffs high in fiber such as corn stover, milo stover, cereal straws, and peanut hulls. However, in recent years increasing amounts of other feeds such as bakery waste, cull fruits and vegetables, brewery and distillery by-products and animal manures have been used as feedstuffs in livestock production. Fortunately for ruminant animals, their digestive system is quite successful in digesting and utilizing roughages which would have only limited digestibility in non-ruminants, i.e., pigs and poultry. The objective in the utilization of these non-traditional feedstuffs by ruminants is to optimize their use in diets to maximize net income. Proper use and supplementation of these feeds can decrease the consumption of more expensive feeds while not restricting animal performance.

The purpose of this paper will be to characterize and illustrate the use of the more common by-product feeds, and also to identify other underutilized feedstuffs which might fit into a nutritional program for breeding cattle and sheep.

Characterizing By-Product Feeds

As can be observed in table 1, by-product feeds vary considerably in their nutrient content. More common feeds such as the stovers and straws are quite low in crude protein (3-6%), high in crude fiber (35-45%) and low in total digestible nutrients or TDN (energy) content (45-55%). For comparative purposes, corn grain has 10% crude protein, 3% crude fiber and 90% TDN while alfalfa hay in early bloom has 18% crude protein, 29% crude fiber and 59% TDN. Therefore, it should be noted that the stovers and straws are low in protein and energy, and the high fiber content may have a deleterious effect on palatability and intake whether they are fed to cattle or sheep.

Conversely, some of the other by-product feeds are high in protein and moderate in energy, and can be utilized to supplement diets containing the stovers

Table 1.--Nutrient Content of Some Underutilized and By-Product Feeds[a]

	Dry Matter Basis					
Feedstuff	Dry Matter %	Crude Protein %	Crude Fiber %	TDN %	Ca %	P %
Alfalfa aftermath	88	20	38	57	2.0	0.30
Barley straw	88	4	42	46	0.3	0.05
Beans (Navy cull)	90	24	5	84	0.1	0.05
Beet tops	20	13	9	8	0.7	0.24
Brewers grains (wet)	24	26	15	81	0.3	0.57
Cattle manure (dried)	92	15	34	35	1.3	0.01
Corn stover	80	6	35	59	0.5	0.09
Corncobs	90	3	36	48	0.1	0.04
Distillers grains (corn)	91	30	14	84	0.1	0.55
Fescue straw	94	4	41	43	0.0	0.06
Grain dust	92	10	15	73	0.3	0.18
Milo stover	85	5	33	54	0.4	0.11
Oat straw	90	4	41	50	0.3	0.10
Peanut hulls	92	7	63	22	0.2	0.07
Peas (cull)	89	25	8	82	0.2	0.43
Pinto bean residue	--	5	--	40	1.5	0.06
Potatoes (cull)	21	10	2	80	0.0	0.24
Poultry litter	86	25	20	64	2.7	1.85
Rye straw	89	4	44	44	0.3	0.10
Soybean (hulls)	91	12	39	71	0.6	0.17
Soybean straw	88	5	44	42	1.6	0.06
Sunflower hulls	90	5	25	40	0.0	0.11
Tomato pomace (dried)	92	23	26	64	0.4	0.59
Wheat straw	88	4	42	44	0.2	0.08
Whey (dried)	94	16	--	82	1.0	0.81

[a]Most data obtained from (21).

and straws. Again, however, bulk and palatability may limit intake such that desired animal performance is not achieved.

The variability in processing procedures is manifested in a variable nutrient content of the by-product feeds and this emphasizes the fact that guaranteed laboratory analyses should be obtained when purchasing each lot of these feeds. If there is doubt about the nutrient content of any feedstuff, a laboratory analysis will pay for itself many times over in the form of reduced supplemental feed costs and/or improved animal performance.

Breeding Beef Cattle

Use of by-product feeds is most appropriate for the beef cow. Over 60 million acres of corn and over 25 million acres of grain sorghum are grown annually in the United States (25). This represents a valuable feed resource for beef cow producers in areas of corn and grain sorghum production.

In spring-calving cows, their energy requirements are lowest after weaning the calf in mid-October through December (table 2). This corresponds nicely with the availability of corn or milo stovers. After January 1, cow needs increase markedly (table 2) as she approaches calving on an average date of March 1. Crop residues, because of their relatively low availability of metabolizable energy, are most effectively utilized in maintenance rations for gestating (dry) beef cows when the energy requirement is at its lowest point (25).

As shown in table 3, a gestating beef cow will be supplied with adequate energy when provided with 20 lb of corn stover either by grazing or feeding out of a stack. However, additional protein, phosphorus and vitamin A will need to be supplied. Dry beef cows allowed to graze an entire field of corn stover preferentially graze the grain, husks and leaves, and stalks in that order (15). Therefore, early in the grazing season there may be little or no response to supplemental protein (25). However, after the first 30 days feeding one to one and one-half pounds of a 40% natural protein supplement will show a positive gain response. Five to six pounds of alfalfa hay or three to four pounds of corn also will satisfy their needs. The use of nonprotein nitrogen such as urea in liquid form and dehydrated poultry waste with crop residues should be limited due to lack of readily available carbohydrates needed for optimum microbial protein synthesis (16).

Calcium content of the crop residues should be adequate for gestating beef cows, however, the phosphorus content will be deficient. A self-fed mineral mixture composed of two-thirds trace mineral salt and one-third dicalcium phosphate (dical) or one-third monosodium phosphate will be sufficient for a non-lactating beef cow. After calving, a self-fed mixture of one-third trace mineral salt and two-thirds dical or one-half salt and one-half monosodium phosphate will be adequate.

Vitamin A levels in crop residues are non-existent and have to be supplemented totally. Injectable vitamin A is a practical method and usually a single injection in the early winter of 2-3 million IU per cow will carry them through the winter.

Although grazing is the most economical way to harvest corn and sorghum residues, there may be situations when it is desirable to harvest and

Table 2.--Daily Nutrient Requirements of Breeding Beef Cattle[a]

Item	Dry Matter	TDN	Digestible Protein	Ca	P	Vitamin A
	----------lb per day----------			---gm---		IU
Mature beef cows (1,000 lb)						
Dry[b]	15-20	8-10	0.45-0.55	13	13	20,000
Dry[c]	17-24	10-13	0.55-0.65	15	15	24,000
Nursing	22-27	12-15	1.10-1.40	27	27	40,000
Yearling heifers (850 lb)						
Dry	16-22	9-11	0.08-1.00	15	15	20,000
Weanling calves[d] (550 lb)	13-17	9-11	0.09-1.10	18	16	14,000

[a] NRC. 1976.
[b] Middle third of pregnancy.
[c] Last third of pregnancy.
[d] Gaining 1.5 lb per day.

Table 3.--Nutrients Supplied by Feeding 20 lb Corn Stover

Item	Digestible Protein lb	TDN lb	Ca gm	P gm	Vitamin A IU
Required by dry cow	.50	9.0	13	13	20,000
20 lb corn stover	.30	10.4	32	8	------
Needed from supplement	.20	0.0	0	5	20,000

store crop residues for use when weather prohibits grazing or when crop production practices require that the ground be tilled prior to the winter months. Provisions for feeding the cow herd under these conditions must be recognized.

Research with pregnant yearling heifers at the University of Nebraska indicated a greater response to supplemental energy and nitrogen when grazing corn stover than did pregnant mature cows (16). Likewise, the additional nutrient requirements of lactating versus gestating beef cows limits the use of crop residues in lactation rations.

In the past ten years there has been interest in chemically treating low quality roughages to improve the digestibility and nutrient availability in these high-fiber materials. Work has been reviewed with beef cows fed corn stalks or wheat straw treated with either 4% sodium hydroxide (NaOH), dry basis, or 3-3.5% ammonia (NH_3), dry basis (20). NaOH and NH_3 treatment significantly increased feed intake and daily gains. However, NaOH places an undesirable residue back in the soil, may interfere with the cow's mineral balance and may increase rate of passage so that maximum digestibility is not obtained. NH_3, on the other hand, increases fiber digestibility, adds a source of nonprotein nitrogen and does not pollute like NaOH does. The disadvantages are that ammonia reacts slower than NaOH, it requires an airtight environment to react and the feed needs to be aerated prior to feeding (20).

Gestating beef cows were wintered in drylot for 100 days on diets composed of alfalfa and bromegrass hays and wheat straw. Wheat straw or wheat straw treated with 4% NaOH, when fed ad libitum with one-third alfalfa hay, supported cow weight gains equivalent to a limit-fed (18 lb DM daily) alfalfa-bromegrass diet. Calf birth weights, calving difficulty and subsequent reproductive performance of the cows were similar for all treatments (1). In other work, rice or barley straw was used to winter pregnant beef cows. Barley or rice straw was fed to pregnant beef cows during the last trimester of pregnancy in rations that were formulated by computer using nutrient composition values based on previous studies. Nutrient specifications and restrictions were placed on the rations; a minimum value of 50 mega-calories net energy for maintenance per hundred weight, 8% crude protein, 0.22% calcium and 0.2% phosphorus, plus either 75% or 85% straw was forced into the rations. Therefore, barley straw was fed at a level of 85% of the diet with corn, cottonseed meal and molasses and rice straw fed at levels of either 75% or 85% of the diet with alfalfa hay or corn grain, cottonseed meal and molasses. During the 127-day feeding period the cows fed the 85% barley straw ration resulted in cow weight loss and severe problems at calving time. As calving time approached, cows fed barley straw became weak, stopped eating and eventually some could not rise. Three out of eight cows calved without assistance. The other five cows had their calves taken by cesarean section. Five calves and only three cows survived on the ration of 85% barley straw. Rice straw fed cows had no difficulty calving and their pre-calving weight gains were adequate. These authors concluded rice straw to be a palatable and satisfactory feed for pregnant beef cows provided protein, mineral and vitamin requirements are met. Diets containing high levels of barley straw are unpalatable even when supplemented properly with protein, minerals and vitamins. They should not be fed to pregnant beef cows unless special precautions are taken to insure that adequate quantities of nutrients will be consumed (13).

Numerous other by-product feeds have been utilized for the gestating or lactating beef cow. However, in many cases, these feed ingredients may be too palatable and nutritious for a pregnant beef cow. Therefore, they might be used to replace some of the higher quality feedstuffs that would normally be fed to lactating beef cows. One by-product in particular, apple pomace, is a by-product of apples used for cider or vinegar production. This product can be fed fresh, ensiled or dried. Two problems have hampered feeding of apple pomace in recent years. Pesticide contamination has been a problem in some areas, making the pomace unacceptable in dairy and beef rations. The second problem is that urea or other nonprotein nitrogen compounds should not be fed with apple pomace due to the possibility of abortions and/or abnormalities of offspring (7).

Perhaps two of the more popular by-product feeds that are being investigated at the present time are brewers grains and distillers grains. Brewers grains have 20% to 25% crude protein on a dry matter basis which makes them a good protein source in addition to their energy value. The brewing process makes this protein less soluble than that for many protein supplements, therefore, it is valued as a supplemental protein source since it contains a high level of bypass protein. Brewers grains can be fed both wet and dried. Because of their high level of energy content, which approaches 80% that of barley grain when dried, and due to their relatively high bypass protein value, they are most likely to be used in feedlot rations rather than in brood cow rations.

The other product which is receiving considerable attention is distillers dried grains with solubles. This is the product obtained after the removal of ethyl alcohol by distillation from the yeast fermentation of a grain or a grain mixture by condensing and drying at least three-fourths of the solids of the resultant whole stillage by methods employed in the grain distilling industry. In the past several years there has been a constant trend toward producing the distillers dried grains with solubles added compared to distillers dried grains and distillers dried solubles which have decreased in importance. The production of distillers dried grains with solubles is now approaching 400,000 tons annually. Nutrient content of distillers feeds depends largely on the composition of the cereal grains used in the fermentation process. Considerable work exists on the use of distillers by-products in the feeding of feedlot beef cattle, however, there seems to be little interest in feeding this particular product to the brood cow. A 50-50 mixture of soybean meal and ground ear corn with distillers dried grains with solubles was compared for wintering 500 lb heifer calves fed grass silage and oat straw. There was no difference in rate of gain over a 182-day period (14).

Crop Residue Utilization by Breeding Sheep

Increasing low cost roughages in ewe rations presents one possibility of reducing ewe maintenance costs. Cornstalks, milo stover and wheat stubble are commonly available to sheep producers in many areas. A study was conducted at Kansas State University to investigate the possibility of using cornstalks as pasture for non-gestating non-lactating ewes (5). One group of 82 ewes grazed seven and a half acres of cornstalks supplemented with one pound of alfalfa hay per head daily. Another similar group was maintained in drylot on six pounds of sorghum silage and one pound of alfalfa hay per head daily. The trial was initiated January 15, and by February 18, ewes on cornstalks had grazed all the grain and let only the less palatable stalks remain. Therefore, ewes on cornstalks were fed one and a half pounds of sorghum grain per head daily in addition to the available grazing and alfalfa hay. After five days, ewes grazing cornstalks had maintained weight, but drylotted ewes gained nearly four pounds each. By the conclusion of the trial on March 2, the ewes in drylot weighed 111 lb while those on cornstalks weighed 104 lb. Difference in weights was significant.

The length of grazing period provided by aftermath for ewes was presented (23). Alfalfa regrowth, in this instance, had an estimated ewe days per acre of 166. Therefore, 17 ewes could graze one acre for ten days or 8 ewes could graze one acre for 20 days. Beet tops provided 344 ewe days per acre while corn stover left in the field provided 887 ewe days per acre.

A study was conducted during the winter months to determine the value of sorghum stover in a maintenance ration for dry, non-lactating ewes (2). Treatments based on dry matter content consisted of six pounds silage of forage sorghum silage and 2.3 lb sorghum stover. Each ewe was fed 1.0 lb of alfalfa hay daily. A mineral mixture consisting of equal parts steamed bone meal, ground limestone and salt was provided free choice. The results indicated ewes fed silage maintained weight while those fed stover lost an average of 13.8 lb during the 28-day feeding period. Dry matter intake of sorghum stover was less than sorghum silage, perhaps, because stover was less palatable.

To determine the performance of lactating ewes and their lambs on roughage, rations consisting of corn, forage sorghum or beet top silage supplemented with alfalfa hay and sorghum grain were fed (3). Ewes were fed 2.0 lb of sorghum grain and 1.0 lb of alfalfa hay per head per day. All silages were fed free choice so that 10% was refused daily. Lamb creep feed consisted of a high energy ration containing 25% roughage and providing 17% protein. The results indicated there was no significant difference in performance of lambs nursing ewes receiving either corn or sorghum diets. Lambs nursing ewes fed beet top silage gained 14% more than those whose ewes were fed corn or sorghum silage. This suggests beet top silage improved milk production. Ewes fed corn or sorghum silage gained significantly more than those fed beet tops, but daily consumption of beet top silages was greatest.

In more recent studies, work has been conducted at Purdue University over the past three years to determine the value of purple top white globe turnips, both foliage and tubers, as a grazing pasture for flushing ewes during the fall breeding season (19). After 60 days of growth, the turnips are ready for grazing. To prevent wastage the turnips were strip grazed by limiting the grazing area to approximately one-half acre at a time through the use of an electrified sheep netting fence. As an area was completely consumed, the electric netting was moved to a new location and the ewes were allowed an additional one-half acre until the entire field was completely grazed. Depending upon weather conditions, grazing extended from approximately October 1 to November 15, a period of 45 days. However, it could be extended until December 1, if weather permitted. During this time the ewes were bred on each of the treatments to determine the flushing effect of the forages used. Comparisons were made with a conventional pasture of tall fescue or Kentucky Bluegrass as controls. The authors concluded the following: 1) Purple top white globe turnips were a satisfactory flushing ration for breeding ewes in the fall. 2) The foliage and the tubers of the turnips should be completely grazed in breaks of approximately one-half acre each. 3) Unsupplemented turnips will allow ewes to gain from 0.1 to 0.2 lb per day while grazing. This appears adequate for flushing purposes and the addition of shelled corn does not appear to be necessary. 4) In wet weather an adjoining grass pasture may provide more comfort for the ewes to bed down at night. 5) The stalking rate of approximately 20 ewes per acre will allow grazing period of from 35 to 45 days. Under favorable conditions this may extend for a longer period of time. 6) A seeding rate of 2.5 lb of turnip seed mixed with 50 lb of 12-12-12 fertilizer per acre appears optimum. This should be broadcast seeded the last week of July and covered lightly with a chain harrow. With favorable weather conditions the turnips should be ready for grazing in 60 days. Turnips do not have to be harvested for sheep since the foliage and tubers can be completely grazed in the field. 7) Conception and lambing rates of ewes flushed on turnips without supplementation were comparable to those flushed on a grass pasture supplemented with shelled corn.

Cull beans and peas make excellent feed for sheep according to results of a U.S. Sheep Experiment Station research project (9). When supplemented by calcium, phosphorus and selenium, cull beans and peas make excellent feed and may cost less than barley. The culls of both legumes are the split, shrunken, broken beans and peas of the industries and generally comprise 3% to 4% of total production. They contain from 5% to 8% dirt and weed seeds. Both cull legumes contain 20% to 25% protein and in practice may be equal to high grade beans and peas in feeding value. Cull peas generally cost the same as barley and the cull beans sell for less than half the price of barley. Dry field beans are grown throughout the world for human and animal consumption. They are an important industry in many states. Dry field peas are commonly raised in the northwestern states for use as human food and as seed peas. Extensive research at the U.S. Sheep Experiment Station, Dubois, Idaho, has shown the following results:

Yearling ewes fed 3.5 lb of whole cull beans and alfalfa pellets consumed 21.6% of the diet as cull beans. When the beans were ground and fed with alfalfa pellets, 20.8% of the diet consumed was beans. Gain per day per animal was 0.3 lb per day. When adult pregnant ewes were fed pea straw cubes containing 27% or 44% cull beans, the gain per day was equal to that obtained by feeding alfalfa cubes. Data from the Michigan Experiment Station indicated that 0.4 lb of cull beans daily proved equal to 0.4 lb of cottonseed meal from the standpoint of lamb production of ewes when fed as a supplement to mixed grass and legume hay during the entire gestation and nursing periods. Adult ewes fed maintenance diets of 57% chopped barley straw, 15.8% liquid molasses, 25% cull whole beans, and premix of vitamins and minerals, or 49.4% chopped barley straw, 13.7% liquid molasses, 35% cull whole beans, and premix of vitamins and minerals maintained weight over an experimental period of eight weeks.

Cull peas and alfalfa pellets were fed the adult ewes in late gestation in varying proportions and at the rate of 4.3 lb per animal per day. The result showed that cull peas may be fed to adult ewes at the rate of 1.75 lb per animal per day without any ill effects. The ewes readily ate the cull peas at all concentrations and no scouring or stomach upsets were observed in eight treatments. These workers concluded that cull beans and peas are an excellent feed for sheep. The cull whole beans may be fed to adult ewes in quantities up to 40% of diet or approximately 1.75 lb per animal per day, to yearling ewes in quantities up to 20% of diets or approximately 0.75 lb per animal per day. Cull peas may be fed to fattening lambs or adult ewes at the rate of 50% of the ration or 1.75 to 2.0 lb per animal per day. Because beans and peas are deficient in sodium, calcium and phosphorus and marginal in such trace minerals as selenium and zinc, trace mineral salt and sources of calcium, phosphorus and selenium must be added to diets containing cull beans and peas. Bean, pea or barley straw, when mixed with liquid and molasses and cull beans or peas in a 50:15:35 ratio mixture and fed at a rate of 3.5 lb per animal per day make an excellent maintenance diet for mature ewes.

The performance of early weaned lambs when fed wheat straw, cornstalks, sudan, or alfalfa as a roughage source was compared in a study in Kansas (4). One hundred fifty-three lambs weaned at approximately 50 days of age were assigned randomly to one of four rations. The rations were composed of cornstalks, sudan, alfalfa, or wheat straw fed as 25% of the ration with soybean meal and grain sorghum comprising the remaining portion of the diet. The alfalfa was ground through a 5/8 in. screen prior to feeding, while cornstalks, wheat straw and sudan were chopped by an ensilage cutter and mixed with the other ingredients in a portable grinder mixer and then fed in self-feeders. All rations contained approximately 13% protein on a dry matter basis. The trial was conducted from mid-December to early June, and the lambs were marketed when they weighed approximately 105 lb. Lambs fed alfalfa hay and cornstalks each at 25% of the ration gain significantly faster than those fed sudan at 25% of the ration. There were no significant differences in average daily gain between lambs fed wheat straw and those on the sudan ration. This study indicated that low quality roughages like cornstalks or wheat straw can be successfully substituted for alfalfa hay for the 25% of the ration that is roughage for growing finishing lambs. The sudan hay was not top quality which may partially explain the poor performance of lambs fed that ration. The cornstalks and sudan rations tended to bridge in self-feeders and had to be forced down regularly. That happened less often with the straw and not at all with the alfalfa. These problems need to be considered when a low quality roughage forage is ground and fed in self-feeders for lambs.

A question always arises whether harvested crop residues should be processed prior to feeding. A study was conducted with 148 gestating ewes evaluating ground or unground cornstalks fed either with alfalfa hay or soybean meal (23). Ewes fed unground cornstalks refused a greater amount of material than those animals fed ground cornstalks. Also, those ewes fed soybean meal refused less stalk than those fed alfalfa hay. The ewes that were fed ground cornstalks had substantially higher lamb weaning rates than those fed unground cornstalks. The problem with processing this type of material is cost. Even though animals have greater performance with the ground material, the return from the animals does not always cover the cost of processing this material.

In summary, it appears that mature sheep are capable of grazing crop residue materials when given an opportunity to selectively graze during a time period of limited snow cover. However, proper supplementation of protein, minerals and supplemental energy when necessary is recommended. In the case of weanling lambs, the use of crop residues and other by-products should be limited to approximately 25% of the diet dry matter. It appears that processing will increase intake in sheep, however, the cost of processing may not be offset by improved sheep performance. Work has shown that vegetable wastes can be used up to 40% to 50% of the diet for adult ewes.

Dairy Cattle

Dairy cattle will eat about 2.5% to 3.5% of their body weight per day when the feed is in a dry form such as hay and grains, but not as much will be consumed if it is high in moisture content. High moisture feeds are often palatable and cows may fill up on such feeds to satisfy their appetites. The result is weight loss and reduced milk production. Better results are obtained when high moisture feeds make up less than half of the total dry matter in the ration. Even when it is economically desirable to feed the maximum amount of wet feed, the ration still should contain at least 0.5% to 1.0% of body weight as dry hay and concentrates. The maximum dry matter intake of an all high moisture ration is about 2.0% to 2.5% of body weight (7).

Large amounts of cull vegetables or fruits can be very laxative and must be fed with care. Dairymen must be aware of possible pesticide residues on fruits and vegetables and should have them tested before feeding them (7).

Other points to be considered when feeding high moisture feeds are the rate of decay of fresh fruits and vegetables and the high labor and transportation costs involved in handling them (7). Some of the more common by-product feeds that are used in dairy cattle rations consist of energy feeds such as beet pulp, brewers grains, distillers grains, citrus pulp and cottonseed hulls. Beet pulp is one of the best by-product feeds for ruminants (7). It is low in protein, however, it contains relatively high amounts of highly digestible fiber. It maintains normal milk fat test when dairy cows are fed restricted roughage ration. It is high in calcium and low in phosphorus. Unfortunately, this can aggravate the undesirably high calcium to phosphorus ratio in rations which contain large amounts of alfalfa or other legumes. Up to 50% beet pulp in dairy concentrate mixes have been used successfully (7). However, its high moisture content and consequent higher transportation costs makes it economically unfeasible to feed wet beet pulp very far from processing plants.

Another by-product feed are the brewers grains. They are not as palatable in the dried forms as the original grain and usually are included as 25% or less of the dairy concentrate mix. Cattle like wet brewers grains and dairymen have fed as much as 80 lb per cow daily with good results (7).

Like beet pulp, citrus pulp is classified as a concentrate, but is also valuable as a partial roughage replacement because of its high level of digestible fiber. It commonly contains about 15% crude fiber in the dry matter. Its energy value is similar to that of beet pulp having about 94% the value of barley grain. It has only about 7% crude protein in the dry matter. Citrus pulp usually is fed dehydrated. It must be introduced gradually into a ration to let cattle get accustomed to its distinctive smell and taste. Once cattle are accustomed, levels of 40% or more of the concentrate mix are highly palatable to them. Citrus pulp can also be fed fresh or as silage. Both are very acceptable to cattle, but pulp and peels from lemons are somewhat more acceptable than those from oranges and grapefruit. Common feeding levels of fresh pulps are about 25 to 30 lb per cow per day (7).

Citrus pulps are high in calcium and low in phosphorus and, like beet pulp, aggravate the high calcium to phosphorus ratio in a ration when fed with legumes such as alfalfa. Unless counterbalanced by other feeds low in calcium and high in phosphorus, this relationship between calcium and phosphorus can result in high incidences of milk fever in cattle at or soon after parturition (7).

Cottonseed hulls are used extensively as a livestock roughage in the southern part of the United States. They are low in protein, calcium and phosphorus and must be supplemented by other ingredients when hulls are the principal roughage. When properly supplemented, hulls are approximately equal to fair quality grass hay. Even though they do not appear so, they are quite palatable to cattle. They can be used as the only roughage in cattle rations, but have greater value when part of the roughage is legume hay, silage or pasture. Hulls are sometimes included in concentrate mixes at low levels to increase the fiber content and bulkiness of a mixture of heavy concentrates. It is particularly helpful in maintaining the fat test in the milk of dairy cows fed restricted roughage and low fiber diets (7).

Distillers dried grains are the by-products of the production of distilled liquors from grains. Corn distillers dried grains contain about 26% protein and are an excellent energy source. They are popular ingredients in dairy rations and are commonly used up to 25% of the dairy concentrate mix. Other grains such as rye, sorghum and wheat are sometimes used for alcohol production, but are of minor importance compared with corn (7).

Utilization of Animal Wastes

Animal wastes represent one of the major underutilized resources in the United States. It has been estimated that 112 million tons of dry waste were produced in the United States in 1974, of which approximately half was collectable (24).

The consumption of waste is natural in many wild and domestic species. The use of swine to follow cattle for the purpose of recycling the waste by feeding has been a common practice for decades, especially in the midwestern section of the United States. Considerable research has been conducted since the middle 50s, especially during the past 13 years on the use of animal waste as feedstuffs for animals (11). Previous reviews on feeding animal wastes have been conducted (6,8,10,22). Reviews on health aspects of feeding animal wastes have been presented (12,17). It has been established that the wastes have a nutritional value for animals, especially ruminants because of their unique ability to utilize nonprotein nitrogen and fiber.

The order of value of animal wastes as feed for ruminants was reported (11) to be as follows:

1. Excrements of young poultry.
2. Deep litter of young poultry.
3. Hog feces.
4. Excrement of laying hens.
5. Hog and layer dung solids.
6. Excrement of cattle.

The nutrient content and digestibility of animal wastes are dependent largely on kind and age of animal, feeding regimen, litter, conditions under which the animals are kept, waste handling practice, and other factors (11).

Data were summarized recently concerning performance of animals fed the different wastes (22). Data from control and experimental cattle fed poultry litter at a level averaging 24% of the diet dry matter indicated that there was a moderate depression in rate and efficiency of gain when cattle were fed the poultry litter diets. This was probably a reflection of lower energy value of litter than the diet into which it was substituted. Comparable data for control and experimental cattle fed dehydrated poultry waste, mainly from caged layers, indicated that performance tended to be higher for the waste fed cattle. Similar improvements were noted when the dehydrated waste was fed to sheep at 17% of the dry matter. Incorporating approximately 12% caged layer waste on a dry basis in rations of dairy cows resulted in similar milk production and dry matter intake as for animals fed control rations. Feeding caged layer waste to dairy cows does not affect composition of or flavor of milk. Likewise, feeding swine waste to swine or cattle waste to cattle did not adversely affect taste of meat.

Processing of animal wastes is important for destruction of pathogens, improvment of storage characteristics and maintenance or improvement of palatability. Heat drying has been used to process poultry, cattle and swine waste although the resultant product is rather dusty. Heat drying may result in loss of nitrogen, at least with poultry waste. Ensiling animal waste alone or with ingredients looks promising, especially in view of the limited supply and high cost of fossil fuel. Cattle waste has been successfully ensiled with grass hay or with other by-product roughages. Poultry litter can be ensiled alone, but the moisture level should be approximately 40% for good ensiling. It may also be deep stacked without ensiling, but it will undergo a heating process (11).

The only disease problem which has been shown to be caused by feeding animal waste has been copper toxicity in sheep fed broiler litter with high copper levels. The problem would not be severe in cattle since they are not as sensitive to high dietary copper. Beef females have been fed diets containing high levels of broiler litter with high copper levels alone and in combination with supplementary copper to add the equivalent of 200 parts per million to the litter during the winter period since 1972. No deleterious effects have been observed (11).

The utilization of animal waste has been shown to be an effective way of disposal of these by-products of livestock production. However, state and federal laws may prohibit the use of these dietary ingredients in some states. Therefore, local regulations should be adhered to and identified prior to feeding animal wastes under livestock production systems.

Summary

In summary, it appears that the utilization of various by-product feedstuffs has not been utilized to the extent possible. Numerous research trials have been conducted with utilization of by-product feeds. However, due to the large numbers of by-products available to the livestock industry and the different performance and classifications of animals that could utilize these feedstuffs, the research has not comprised all the possible combinations of resources and livestock that would be possible. However, there is enough data available to indicate that we could certainly use more of these feedstuffs than are presently being utilized. Future research under conditions requiring higher levels of animal performance will indicate the upper limit of utilization of these feeds. The economics of using these feedstuffs needs to be continually addressed. In the meantime, producers should continue to examine alternative feedstuffs which can reduce the cost and improve the efficiency of livestock production.

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FINISHING RUMINANTS WITH HIGH ROUGAGE RATIONS

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ABSTRACT

Several conditions, such as economic pressure, costs of energy inputs, continued loss of our soil resources, projected increases in world population, limited water supplies and potential world demand for grain, are at work to make finishing of ruminants with high roughage rations a viable approach to meat production. The small farmer can adapt livestock production to a forage-feeding system with a relatively low investment. Maximal forage-feeding throughout the animal production period will minimize feed costs. Several new techniques are becoming available for increased production of forage-fed meat animals along with methods to improve carcass quality for consumer.

Key words: Cattle, forage-fed market animals, forage supplements, pastures, sheep, small farms, type of forage.

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For a number of years, predictions have been made that finishing ruminants for market on high grain rations would become uneconomical. Several forces are now at work that may accelerate greater use of forages in livestock feeding programs. Energy inputs required for intensive, high yield crop farming are becoming much more expensive. This will make grains economically unavailable for livestock. At present, the consumer has put a price ceiling on meat purchases so producers are forced to cut feed costs by utilizing more forages.

About one-third of our top soil has been lost to erosion resulting in a considerable loss of soil fertility (22). Three million acres of prime farm land (12 square miles) a day are lost to agriculture (14). The use of lands for forage production could reduce erosion loss but land used for commercial development will be lost for food production.

World population is projected to increase to about six billion people by the year 2000. Future population growth rates may be slower but enormous numbers of people will be added to this planet (19).

The water supply for growing corn in the high plains states where 40 percent of the grain-fed beef is fattened is dropping (30). Limited water supplies in that area may force a return to dry land farming or an alternate cropping system to corn.

Projections for grain and oilseed needs in the 1990's are for 420 million metric tons more than we produce now in order to meet world demands. It is doubtful if the U.S. can increase its production of these commodities to supply such a demand (10). World cereal grain deficit is projected to be 84 million tons by 1990 (31). Pressure for human needs will remove the availability of grains for extensive feeding of livestock. A trend towards feeding by-product feeds and high roughage rations is underway now due to economic conditions, but by the 1990's grain availability may dictate the use of high roughage rations.

How can the small farmer benefit from finishing ruminants on high roughage rations? There is, of course, a large economic advantage in reduced costs of feed inputs. Many small farmers maintain continuous ownership of cattle or sheep from birth to market and can make maximal use of roughages and pasture. Low quality roughages can be used for over-wintering periods when gains can be reduced and pasture can be utilized for periods requiring more rapid growth. The farmer must accept a longer growing period with reductions in gains, carcass grade and carcass tenderness. For example, yearling Santa Gertrudis steers fed grass only for 241 days gained 113 kg; whereas, steers fed grass plus grain ad libitum for the final 60 days gained 139 kg. The grass-fed steers had a lower carcass fat content, a higher lean content, less desirable flavor and lower carcass grade (1,4).

Electrical stimulation of carcasses may be an effective method of improving the tenderness of beef (6), particularly beef in the low grades (27). A combination of electrical stimulation, delayed chilling and pelvic suspension of carcasses from forage-fed steers may improve tenderness (28).

The most common nutrient deficiency in forages is available energy (2,7). This means that some grain supplementation for finishing ruminants on pasture will usually improve animal growth. Forage intakes of cattle will be about 2.7 to 2.9 percent of body weight and body weight gains up to 1 kg daily can be expected. Cattle fed concentrates can be expected to gain about 30 percent faster and spend 25 percent less time in the feedlot than those fed a high quality forage (7). Lambs fed grain in a drylot will also reach market weight about 20 percent faster than those on pasture with no grain (9).

Type of supplement or additives may have an effect on the growth of pastured livestock. A pasture experiment with ewe lambs grazing plots containing mixed grasses showed that type of protein fed produced differences in growth. The lambs that were fed a combination of soybean and fishmeal protein were taller, but not heavier, than the lambs fed the soybean diet (16). Monensin, a non-hormonal feed additive, is effective for increasing weight gains of forage-fed cattle. Daily gains of stocker cattle (heifers) on wheat pasture (12), feeder steers on winter pasture (18), calf gains on Bermudagrass pasture (24) and finishing cattle on forage diets (8) were increased by monensin. In the last work, the effect of monensin and a hormonal implant were additive. Much more can be learned about the use of proper supplements for maximizing animal performance with high roughage feeding programs.

Several factors influence the nutritive value of forages hence the growth response of animals. Pastures containing high quality grasses and legumes at the optimal stage of maturity will produce the greatest intake and consequently an optimal level of animal performance. Temperate grasses decline in nutritive value with maturity; with approximately 69 percent TDN in young grass, 64 percent in bloom and 54 percent at maturity (20). Lambs grazing perennial ryegrass or ryegrass-white clover pastures showed a gradual decline in growth with advance in the grazing season (15). The estimated TDN content of consumed forage from cattle grazing studies also showed a seasonal decline (5). Certain other types of forage can be utilized to increase animal production. Adapted varieties of perennial ryegrass could be used for raising spring market lambs, the high seasonal performance of smooth bromegrass for lambs suggests that it might be more extensively utilized in pastures. Both orchardgrass and ryegrass produced improved seasonal body weight gains than did fescue (23).

In some instances, the farmer may not want to maximize animal gains but maximize productivity for a limited land area. This may be the case for many small farmers. A recent study of ewes and lambs on hill pasture (25) showed that as stocking rate increased body weights were decreased but at the highest stocking rates used more kilograms of lamb were weaned per (acre) hectare. This means that the small farmer has several options available for pasture management to maximize returns.

A plant growth regulator, mefluidide, reportedly maintains pasture grass in the rapid growing vegetative state for longer periods during the grazing season. The application of mefluidide directly to pasture in the spring may effectively increase pasture production and improve digestibility (11).

A summary of several studies with dried forage showed that steers fed alfalfa gained nearly twice as fast as steers fed orchardgrass and 25 percent faster than those fed timothy hay. Cattle fed timothy-clover hay grew at the same rate as those fed alfalfa. The author concludes that cattle fed diets containing some high quality legume will grow at almost the same rate as those fed all-legume diets (7). This points to the important role of legumes in a livestock forage program for the small farmer. Pelleting alfalfa hay and corn plants harvested at late silage stage, for market lambs increased growth and carcass grades. The authors concluded that finishing market lambs with forage diets was possible (3).

Considerable interest has been shown in ammoniation of roughages for ruminants. Preservation and the nutritive value of forages was improved by ammoniation. Forages included are large round bales, stacks of rectangular bales and low quality forages stored in silos. The nitrogen content of the stored roughage and the dry matter digestibility was improved (21). The ammoniation technique might be particularly useful for the preservation of incompletely cured hay in areas where spring hay making is difficult (13).

Silages are an important and economical feed for ruminants fed high-roughage rations. The use of silages is probably better adapted for large farmers than the small farms; nonetheless, plastic bags or trench silos as well as the conventional upright silos can reduce animal feed costs for the small farmer. Recent work has shown that formic acid added to direct-cut silage at the time of ensiling improves recovery of nutrients from the silo, animal intake, daily gain and gain per ton of forage stored (29). Future research may suggest practical methods to improve the availability of protein in silages to further improve the nutritional value of silage in forage feeding programs.

Trends in livestock selection in recent years have been towards large frame size and maximal gain for drylot in high grain feeding systems. The question arises, "are these large animals best suited for maximal returns utilizing high roughage rations?" In one experiment, steers were classified by frame size and their postweaning growth evaluated under forage feeding conditions. There was little advantage in daily gain for the large frame steers. Under conditions of restricted growth, large frame steers have little advantage over the small frame steers with their lower overhead costs (17). It would be important for the small farmer to be able to select the most profitable type of livestock to fit a forage feeding program. More information is needed in this area.

Intact males fed under feedlot conditions showed a 17% increase in daily gain and a 13% better feed conversion than steers. Rams also gained faster than wethers. The increased gain of intact males vs. castrates under a low plane of nutrition or under pasture conditions may not be as great (26). More information is needed to show how the increase in growth potential of the intact male can be utilized under forage feeding programs.

The small farmer has the advantage of being able to adapt a livestock enterprise to produce market animals under high roughage feeding programs. New developments in feeding management and forage research should help maintain increased animal production.

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SMALL ANIMAL ENTERPRISES FOR SMALL FARMS

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ABSTRACT

Small animal enterprises on small farms such as rabbits, goats and poultry, can produce meat and eggs for home consumption.

The domestic rabbit produced at a comparable value of $1.25 per pound has a potential as a meat animal for home consumption. Commercial rabbit enterprises appear not to be economically feasible in Northern New England but direct marketing may improve returns. Rabbits are adaptable to both small and large scale production. Profitability is presently limited because of the labor intense management requirements, cost of feed and disease problems.

The dairy goat has a potential for home production of milk, valued at about $2.90 per gallon and meat, valued at about $1.50 per pound. Supplemental income is possible from the sale of surplus milk, chevon and kids.

Poultry raised on small farms can provide eggs at about $.79 per dozen and fowl for meat. Sales of poultry, such as capons raised for holiday meals, provide small farmers with an opportunity for supplemental income.

Key Words: Dairy goats, direct marketing, poultry, small animals, small farms and rabbits.

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INTRODUCTION

Small and part-time limited resource farmers need economic information about small farm enterprises in order to make informed decisions about the optimal use of their resources. The purpose of this paper is to present economic information on three small farm enterprises namely domestic rabbits; dairy goats and poultry. The economic information will describe the use of these small enterprises for production of food for home consumption and for generation of farm income.

LIMITATIONS OF PAPER

The length of this paper does not provide space for a complete discussion of the three small animal enterprises. Price information was collected from Northern New England vendors and buyers, subsequently the projected costs and returns reflect only those of that region. Obviously, some regions of the United States have comparative economic advantages to Northern New England.

DOMESTIC RABBITS

Domestic rabbits have great potential as a meat producing animal. They can provide more meat from forage based diets than any type of livestock (3). Rabbits are adaptable to either small scale or large scale production. Profitability of commercial rabbit production is currently limited and results in low returns to labor, management and investment. Other problems include labor intensive management, severe disease problems, the lack of knowledge by raisers of nutritional requirements and the effects of nutritional inadequacies on the development of enteric diseases.

Home Consumption

Most small farms have the resource to produce domestic rabbits. A domestic rabbit herd of eight does and one buck can produce from 726 pounds to 1,400 pounds of liveweight meat for the farm family, depending on management and climate (2). Rabbit meat is all-white, fine grained and high in protein. Only about 20 percent of the dressed carcass is bone, so that meat yield is high compared with that of many meat animals (6).

The feed to meat conversion ratio for rabbits, with a high energy concentrate, is estimated by the U.S. Department of Agriculture to be about three pounds of pellet grains plus a free choice of good quality legume hay to produce one pound of meat. The dress out, including heart and liver should be about 55 percent. The edible portion of the carcass could be nearly 80 percent. These figures compare favorable with that of broilers and fryers.

The economics of raising rabbits for home consumption are based on the following assumptions.

1. Herd size = 8 does and 1 buck.
2. Each doe will have 3 litters per year, averaging 7 fryers per litter. Death loss will be constant through the year.
3. Commercial rabbit feed will be used.
4. The buck and 50% of the does will be replaced each year.
5. Death loss of does will be 12% per year.
6. Suitable housing is available.
7. Family labor is not considered as a cost item.

The initial investment is an estimated $368. This includes $135 for brood stock, $180 for cages, $45 for nest boxes and $8 for feeders and waterers.

Rabbit enterprises are a dreamer's delight in terms of the potential number of rabbits one could produce. Rabbit producers must be cautious with their production expectations. The gestation period of a rabbit is 31 days and a good doe usually averages seven young per litter. Since a doe can be bred again five weeks after the young are born, idealistically a doe might be able to produce six litters each year. This would result in the yearly production of 42 fryers. However, three litters per year might be more realistic because of physiological limitations and stresses placed on a doe during pregnancy and lactation. Therefore, an estimated 21 fryers may be raised per year - half the number anticipated in an ideal situation. Considering death loss the herd production will be 147 fryers, averaging 4.7 pounds liveweight each (or 690 pounds of fryers). Four culled does and the culled buck will also provide 36 pounds of meat. The total liveweight production of 726 pounds of rabbits converted to a 55 percent dress out will represent about 400 pounds of rabbit meat at a cost of about $1.25 per pound.

The economics of raising rabbits will vary with breed raised, the housing available, the type of feed used and the degree of management provided.

Annual production costs for home consumption are estimated as follows:

ITEM	TOTAL HERD	PER DOE
Purchased Feed 1.6 ton @ 243.08/ton (400 lbs/doe x 8 does = 3,200 lbs.)	$389.00	$48.00
Medication	6.00	.75
Utilities	7.00	.88
Misc. (supplies, transportation, etc.)	10.00	1.25
Interest on Investment ($368 x 15%)	50.00	6.90
Depreciation	35.00	4.37
ESTIMATED TOTAL ANNUAL COSTS	$502.00	$62.15

Rabbit Enterprises

The raising of domestic rabbits, as a farm enterprise for supplemental farm income, has been steadily increasing in the United States. In some

Table 1.--Rabbit Fryers Enterprise Budget (Oregon State Format)

Based on the following assumptions:

1. Family Operation
2. 150 Working Doe Herd
3. 5½ Litters per Year
4. 7 Fryers Raised per Litter
5. 19 Bucks
6. 50% of Does Culled per Year
7. 12% Death Loss of Does per Year
8. 9 Bucks Replaced per Year
9. Rabbits Marketed Live to Processors and Distributors

	INITIAL VALUE	AVERAGE LIFE (YEARS)	DEPRECIATION	INTEREST ON INVESTMENT[1]
Estimated Investment:				
Land (1 acre)	$ 2,000			$ 180
Housing	14,000	10	$1,400	840
Cages	3,000	10	300	180
Feeders and Waterers	1,200	10	120	72
Feed Storage	800	20	40	48
Other Equipment (feeder cost, disposal pit nest boxes and misc. equipment)	1,000	5	200	60
Rabbit Inventory	2,000			180
TOTAL INVESTMENT	$24,000		$2,060	$1,560

	TOTAL HERD	PER DOE
Estimated Returns:		
Fryers (5,673 hd. @ 4.7 lbs./hd. @ 56¢/lb.)	$14,931	$ 99.54
Culls (75 does & 9 bucks @ 9 lb./hd. @ 30¢/lb.)	227	1.51
TOTAL ESTIMATED RETURNS	$15,158	$101.05
Estimated Expenses:		
Feed (53.32 tons @ 243.08/ton)	$12,961	$ 86.41
Medication	100	.67
Utilities	200	1.33
Repairs and Maintenance	150	1.00
Property Taxes	150	1.00
Misc. (supplies, transportation)	200	1.33
TOTAL ESTIMATED CASH EXPENSES	$13,761	$ 91.74
Estimated Return above Cash Expenses Shown	$ 1,397	$ 9.31
Estimated Non-Cash Expenses:		
Family Labor (1,825 hours @ $3.35/hour)	$ 6,114	$ 40.76
Interest on Investment	1,560	10.40
Depreciation	2,060	13.73
TOTAL ESTIMATED NON-CASH EXPENSES	$ 9,734	$ 64.89
TOTAL ESTIMATED EXPENSES (cash and non-cash)	$23,495	$156.63
Return to Management	($-8,300)	($-55.33)

[1] Computed at 12% on ½ the initial value, except land and rabbits which was 9% of initial value.

areas it is considered to be a commercial agricultural alternative. As the rabbit industry grows, better methods of processing and greater efficiency in production are certain to become a reality. With improved marketing procedures, a stable outlet for this kind of meat could be forthcoming. The American Rabbit Breeders Association Market Report indicates that 16 processors located nationwide offered an average of $.56 per pound liveweight basis for white rabbits and $.52 per pound for colored rabbits, delivered to the plant. The range of prices were for white rabbits $.48 to $.68 and for colored rabbits $.32 to $.60 (1).

The projected costs and returns on a 150 doe commercial enterprise have been made using a detailed rabbit enterprise budget format from Oregon State University. In a commercial rabbit enterprise a controlled environment is provided by housing facilities, therefore 5½ litters per year is expected (see table 1).

Under the assumed production conditions, practices and prices of the budget it appears that domestic rabbit enterprises in Northern New England will not provide a profit to the producer at this time. Opportunity for sales to commercial rabbit processors may be also limited in many regions. The

Table 2.--Dairy Goat Budget (4) (10 Doe Herd)

ITEM	QUANTITY	PRICE	TOTAL PER HERD	PER DOE
Returns:				
Goats Milk	1800 lbs.	$ .36/lb.	$6,480.00	$648.00
15 Kids		15.00 ea.	300.00	30.00
Cull Does (3)	3 @ 66 lbs.	.45/lb. (liveweight)	99.00	9.90
TOTAL ESTIMATED RETURN			$6,859.00	$685.90
Expenses:				
Relacement Doe	1/3	$100.00 ea.	$ 330.00	$ 33.00
Buck Costs	1/4	100.00 ea.	250.00	25.00
Feed				
Alfalfa Hay (1 ton @ $80.00)			800.00	80.00
Concentrate (2#/day/doe 300 days)		3.58 ton	2,148.00	214.80
Taxes			80.00	8.00
Insurance			30.00	3.00
Supplies and Repairs			70.00	7.00
Electricity			80.00	8.00
Marketing and Distribution Expense			72.80	7.28
Veterinary and Medicine			20.00	2.00
Bedding			2.00	.20
Depreciation				
Housing ($1,000; 25 years life)			40.00	4.00
Equipment ($300; 10 years life)			30.00	3.00
Feed Storage ($300; 10 years life)			30.00	3.00
Interest on Investment at 9%				
Land (3 acres @ $250)			67.50	6.75
Building and Equipment_(½ cost $800 @ 9%)			72.00	7.20
Does $100/hd.			90.00	9.00
TOTAL ESTIMATED EXPENSES			$4,230.30	$423.03
Returns above Costs Shown			$2,629.70	$262.97

cost of feed and labor (at minimum wage rate) are the most significant expenses. The degree of profit or loss will vary with the availability of resources and the management abilities of each producer.

Consideration as to opportunity for direct market sales should be made by the producer. Direct marketing of dressed fresh or frozen rabbit carcasses from a producers home, may be economically feasible if permitted by state law. Price differentials may exist between wholesale and/or liveweight prices and retail prices of dressed rabbit meat. There would also be an added by-product, the pelts which would increase returns.

DAIRY GOATS

The small farm family may find it more convenient and economical to keep one or two dairy goats rather than buy milk or keep a dairy cow. Goats do not need any special kind of housing, but should be protected from rain, snow and cold. They are natural climbers and can tolerate the steepest pasture.

Home Consumption

During the summer a goat needs pasture and 1 to 1½ pounds of grain per day. During the winter a dairy goat will consume 2 or 3 pounds of hay and 1 to 2 pounds of grain per day. Goats will also eat beet tops, bean and bean vines, sweet corn stover and other garden wastes.

A good dairy goat produces at least 2 quarts of milk valued at about $2.90 per gallon daily for 8 to 10 months of the year and can be fed for much less than the cost of feeding a dairy cow. Goats milk may not be as palatable to people who are used to the taste of cows milk. However it is as nutritious, and goats milk can often be tolerated by infants and persons who are allergic to cows milk.

Each doe will produce 1 or 2 kids each year. Doe kids can be raised for replacements, buck kids can be raised for meat for the family or raised and sold as chevon. The value of chevon is about $1.50 per pound.

Dairy Goat Enterprise

Before developing a dairy goat enterprise a farmer must consider the demand for goats milk in the area of the farm. Usually the demand for goats milk will not be great enough to provide for distribution. Farm sales will most likely occur. A way to expand sales of goats milk is to consider processing it to expand it's value. Goats cheese and goats milk ice cream are two products that

Table 3.--Chevon Goat Budget (10 Wether Goat Herd)1/

ITEM	QUANTITY	PRICE	TOTAL PER HERD	PER GOAT
Estimated Returns:				
Sale of Chevon	900 lbs.	$ .55/lb.	$495.00	$49.50
Estimated Expenses:				
Cost of Goat Kids	10	20.00/ea.	200.00	20.00
Feed				
Timothy Hay	.30 tons	50.00/ton	15.00	1.50
Grain (Corn Equivalent)	60 lbs.	11.34/cwt.	6.80	.68
Concentrate	100 lbs.	17.30/cwt.	17.30	1.73
Taxes	2%	200.00	4.00	.40
Insurance	5%	200.00	10.00	1.00
Supplies and Repairs			5.00	.50
Marketing and Distribution Expense			20.00	2.00
Bedding			2.00	.20
Depreciation				
Housing ($1,00; 25 years life)			40.00	4.00
Interest on Investment at 9%				
Land (3 acres @ $250)			67.50	6.75
Building (½ cost 800 @ 99)			72.00	7.20
Goats $10/hd.			9.00	.90
TOTAL EXPENSES SHOWN			$498.60	$49.86
Return above Costs Shown			($ -3.60)	($ -.36)

1/ Assumes ample available pasture.

may be considered. The economics of dairy goat enterprises are shown in table 2.

Another goat enterprise involves raising wether bucks or cull does for chevon. Chevon is in high demand in the Northern New England area. This enterprise compares very favorably with market lamb production. The economics of this enterprise is shown in table 3.

POULTRY

Most small farm families have always raised poultry for eggs and meat. However, with the development of poultry and egg industries during the last 4 decades and with the ever increasing costs of commercial poultry feed in Northern New England, many of the incentives for home production were reduced. Price of poultry products is of course an important consideration. With recent years of inflation, the difference in the cost of producing poultry products and purchasing them may have narrowed. Raising poultry and producing eggs may once again become economically sound as well as being an enjoyable farm family activity.

Table 4.--Capon Budget (4) (100 White Rock Capons - 14 Weeks)

ITEM	QUANTITY	PRICE	TOTAL PER HERD	PER BIRD
Estimated Returns1/				
Capons (8 lbs.)	85	$1.25 lb.	$850.00	$8.50
Roasters (6 lbs.)	15	.70 lb.	63.00	.63
TOTAL RETURNS			$913.00	$9.13
Estimated Expenses:				
Direct Costs				
Chicks	125	.25	$ 31.25	$ .31
Feed				
Broiler Feed	3700	.12 lb.	444.00	4.44
Whole Corn	1300	.12 lb.	84.00	.84
Caponizing Cost	125	.20	25.00	.25
Brooding Cost, Misc.	125	.20	25.00	.25
TOTAL EXPENSES SHOWN			$609.25	$6.09
Returns above Costs Shown			$303.75	$3.04

1/ Assume 20% mortality.

Home Consumption

A recent home consumption analysis of a 12 pullet flock of laying hens indicated that a laying hen during her growth from a chick and the first year of her production will consume around 140 pounds of feed. In the first year she will produce about 20 dozen eggs (5). At an average feed cost of $11.25 cwt. in Northern New England and considering no chick cost and no value, the cost of eggs is $.79 per dozen. A farm family cannot only gain some enjoyment while observing a flock of chicks grow to adulthood but, may also gain laying pullets and cockerels for broilers and capons for home consumption.

Poultry Enterprises

There are numerous poultry enterprises that small farm families may wish to consider. Some farmers are raising replacement pullets, capons, ducks, geese, turkeys, and even exotic fowl such as guinea fowl and game birds including pheasants and quail. The length limits of this paper prohibit description of the economics of each enterprise. However, a supplemental capon enterprise that produces meat birds for holiday meals will be considered.

Capons are castrated meat type cockerels raised to about an 8 pound average. They are considered a delicacy for holiday meals because of the quality of their meat. Prices for capon are different from those of other fowl because of this preference (see table 4).

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VETERINARY AND HEALTH ISSUES CONFRONTING SMALL FARMS

Paul Becton 1/

ABSTRACT

Animal health plays a key role in any successful small farm livestock operation. Disease prevention and control are essential concerns of the livestock producer regardless of the size or type of operation. The small farm operation offers both advantages and disadvantages in terms of maintaining healthy livestock. Effective utilization of a private veterinary practitioner can be extremely valuable to the small farm owner. A proper mixture of professional consultation and treatment, disease preventive management, and home care will provide an excellent basis for on-the-farm animal health. Other resources should be utilized in the local community as an aid in promoting healthy livestock on the farm. Extension Service; farm and livestock associations; libraries; and county, State, and Federal animal health officials can all assist the small farm owner in terms of animal health. Good management and marketing practices can also be valuable in protecting livestock health and preventing disease. Small farms producing livestock or livestock products for home consumption should also be aware of endemic diseases transmissible to man. Many animal disease problems can be prevented or eliminated entirely by sound planning and by fully utilizing the veterinary resources available in the community.

Keywords: Animal health, home care, home consumption, management marketing, small farms, treatment, veterinarian, veterinary issues, zoonotic diseases.

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Animal health concerns confronting the small farm operator today are numerous. With high interest rates, increasing production costs, and low profit margins, the low volume livestock producer must be especially concerned with animal disease and production losses. Even the farmer interested in animal production simply for home consumption must strive to produce healthy animals in order to profit from his work. What may start out as a promising small livestock operation may prove to be a costly and frustrating experience when a producer is confronted with animal disease. In this discussion, a number of areas that should be of concern to the operator of a small farm in terms of animal health will be presented. Much can be done by the producer to minimize animal disease problems and maximize production with relatively low costs.

ANIMAL HEALTH AND THE SMALL FARM - ADVANTAGES AND DISADVANTAGES

The owner of a small farm has both advantages and disadvantages in terms of maintaining animal health compared to the large and more specialized livestock producer. In most small farm operations, facilities, labor, and investment capital are at a minimum. High quality animals may not be available and the relatively small number of animals involved may limit the producer's management options. On the other hand, the small farm owner or operator may in fact have greater flexibility and diversity in some aspects of his operation.

Major changes in operation can often be made quicker and more easily by the small farm owner. The smaller number of animals can allow the producer to more easily identify health problems in individual animals and offer individual treatment and prevention programs. The owner of the small farm is often more directly involved in all aspects of his operation and can have a greater direct control and input into any operation decisions.

The consequences of disease can be just as serious to the owner of a small farm as to the large scale producer. The loss of a single animal, or production losses over a short period, may result in a net loss to the livestock operation. The livestock producer on a small farm must view the maintenance of animal health as one of his most important concerns since the health of the individual animal may determine the success or failure of the operation.

UTILIZING A VETERINARIAN

Proper utilization of a local veterinary practitioner is one of the most important elements in raising healthy and productive livestock. Unfortunately, many small farm owners are reluctant to use their local veterinarian because of the added cost to their operation. Most often the cost is much greater to the livestock owner who will not make use of this animal disease specialist.

The small farm owner should become acquainted with the local practitioner whether he intends to raise only a few or a large number of livestock. Discussing plans for establishing a livestock operation with a veterinarian in the area may prove very valuable in determining the type and number of animals to raise. The veterinarian can often provide good information on where to initially obtain healthy animals, good management practices in the area, and practices that might prevent disease problems.

It would be valuable for the small farm operator to visit the veterinarian in his office. The veterinarian would be interested in the type and extent of the producer's livestock operation, and it would be advantageous to both producer and veterinarian if their first meeting does not occur as a result of a middle of the night emergency. Much can be learned from a veterinarian practicing in the vicinity of the farm. He will be knowledgeable of disease conditions affecting livestock in the area and can recommend disease prevention measures that can be applied on the farm. The veterinarian can recommend a vaccination program against diseases commonly occurring in the area. He will be knowledegable of local parasite problems and can recommend a prevention or control program to protect livestock. The local veterinarian may also be able to assist the small farm operator in developing a livestock breeding program as well. Initial disease diagnosis should be made by the veterinarian, and generally any surgical or otherwise difficult procedures should be left to the professional. The administration of antibiotics or drugs to farm animals by the owner should be carefully discussed with the veterinarian. The label instructions regarding dosage and method of administration on any medicine should be followed precisely. It is also important to follow label directions carefully in withholding milk from market channels and waiting the proper interval before slaughtering treated animals. The local veterinarian should be involved in the choice of drug treatment and can provide information on the withholding times on various drugs.

The veterinarian can be invaluable to the small farm operation if used wisely. It should be remembered that the veterinarian in farm animal practice is a busy professional and must utilize his time to the best advantage. Although he most often works with larger, more intensive livestock operations, he generally is very willing to work with small operations as well. The producer can assist the veterinarian in a number of ways in order to best utilize his time. When a veterinarian is called out to a small farm, the visit should be scheduled to allow the owner or operator to be present when the veterinarian arrives. The animals to be examined or treated should be caught and restrained. The veterinarian can then discuss the health problem with the owner, examine the animal or animals without delay, and concentrate on recommendations for treatment and prevention. The veterinarian will appreciate the owner's interest and assistance in providing accurate and complete information on the problem. Generally within a short time the veterinarian and the owner can work out a plan of action to successfully begin solving the problem. This may include laboratory submissions for diagnosis, a treatment program for diseased animals, and preventive measures involving other livestock.

Most veterinarians today are mindful of the cost of their services, especially to the small farm operator. Often an owner can rely on the veterinarian to limit his role to one of consultation and initial treatment, recommending that the owner carry out any necessary followup treatments.

The small farm owner may often assist the veterinarian by bringing young or small livestock into the veterinary clinic, saving the cost of travel time to the farm. The owner may even be able to assist in delivering samples from his animals directly to a laboratory, thereby, reducing the veterinarian's charge for performing this service.

The livestock owner should discuss with his veterinarian potential, as well as actual, disease problems and determine what he, as the owner, can and should do in terms of checking for disease signs, treatment, and prevention. Many veterinarians will encourage extensive owner participation in the treatment and care of his animals. It is best to involve the veterinarian early in a disease problem and follow his recommendations carefully. Consultation and visits by the veterinarian will add to production costs but will save money in the long run.

OTHER COMMUNITY RESOURCES

The local veterinary practitioner is not the only resource available to the small farm owner in regard to animal health. There are a number of resources in the community which can provide information and assistance on prevention and control of livestock disease.

The Extension Service provides assistance in distributing written materials, sponsoring lectures, and arranging discussions on local animal health concerns. Extension veterinarians are available in all States to provide county offices with veterinary information and can assist in solving special animal health problems in the local area. The extension office can serve as a valuable link between recent developments in the prevention, treatment, and control of disease and the small scale farmer. The extension office can provide a great deal of assistance to the farmer at little or no cost. Information can be obtained on nearly all facets of animal husbandry, livestock management and production, and animal health issues in the local area. The extension office can also direct the livestock producer to other sources of assistance within the community.

In some areas of the United States, the county government employs a veterinarian to assist the community with local animal health problems. As the chief animal health official in the county, this individual works on local animal disease problems, animal control issues, and on animal diseases which may affect the public health. The county veterinarian is an excellent source of information on animal health, and can be especially useful to the small farm owner as a community resource.

Also valuable to the small scale livestock producer are livestock and farm associations in the community. A number of livestock breed associations also have State or local chapters. All of these organizations are concerned with animal production and often focus on animal health issues. Local and national publications provide information concerning disease and health problems which affect livestock. There are also a number of youth groups which provide training in animal husbandry, management, and health issues. The small farm operator may want to investigate these organizations in his community and take advantage of the information they can provide.

The community library is also a valuable source of information regarding livestock health. The library can provide direct access to animal health publications and also provide listings of Government or private publications available upon request. This resource should not be overlooked by the farmer seeking information on raising healthy livestock.

State and Federal animal health officials can also provide information and assistance to the small farm owner. These officials are involved in the control and eradication of a number of livestock diseases and act to prevent the movement and sale of diseased animals. There are State and Federal veterinarians working throughout the United States to eliminate diseases such as brucellosis, tuberculosis, scabies, screwworm, and scrapie. They also investigate outbreaks of disease and prevent the introduction of diseased animals from other countries or parts of the United States. Federal or State veterinarians can provide information on disease programs, animal health regulations, and the status of a number of diseases in various States and areas of the country. State diagnostic laboratories can provide assistance in testing for a number of diseases and conducting postmortem examinations on livestock. This service is provided at nominal or no charge to the livestock producer.

MANAGEMENT PRACTICES AFFECTING ANIMAL HEALTH

Management practices affecting animal health can be very important to the small farm operator. The type of animal production, facilities available, and environmental factors on the farm should be considered in terms of livestock disease problems. Good management practices can prevent many health problems from arising at all.

The owner of a small farm must decide on the type and number of animals best suited for his operation. Certain species of animals should not be housed together. Leptospirosis may be a problem when swine and cattle are mixed. Malignant catarrhal fever may be a problem in cattle housed or pastured with sheep. Overcrowding can lead to sanitation problems and high exposure during disease outbreaks. Adequate facilities must be available to suit the number and kind of livestock to be raised.

One phase of livestock production may be more suitable to existing facilities on the small farm and they can affect the health status of the animals. Respiratory diseases and intestinal parasites are of critical importance in a veal calf operation, whereas reproductive problems or diseases of the newborn are more important to the cow calf operator. Any type of animal production will entail specific disease concerns, and the choice of management should include the prevention, control, and treatment of problems associated with the type of production.

A major management decision affecting the health status of livestock is in selecting an open as opposed to a closed type operation. In a closed operation, breeding is carried out on the farm and replacement animals are raised on the premises. In an open operation, new stock are introduced from outside the herd periodically. The disadvantage of the open type of operation is that newly introduced animals may be harboring disease. Often the open type of operation is necessary to introduce new genetic stock or just to maintain a balance of animals in the herd. Isolating new animals and testing them for diseases prior to commingling may be very important in maintaining herd health. Current recommendations to prevent the introduction of cattle affected with brucellosis into a herd include testing, isolating new animals for 45 to 120 days, and retesting prior to mixing the cattle with the herd. In certain areas, this preventive measure is required by State law if the animals purchased originate from certain higher incidence brucellosis areas of the country.

A farmer raising feeder animals can also protect the health of his livestock by using an "all in, all out" type of management. If animals can be purchased as a pre-existing group and maintained together until sold as a group, there is much less risk of an outbreak of disease. Buying animals from various sources and assembling them on a farm is especially dangerous in terms of disease control. The "all in, all out" rearing method prevents the mixing of a number of carrier and susceptible animals at one time. Such exposure can be explosive in a disease outbreak.

Other management practices will lessen the risk of disease or health problems in any livestock operation. Vaccination or parasite control programs can be very valuable to livestock owners on small farms. The small farm owner may choose to use artificial insemination rather than natural breeding to reduce the risk of introducing male animals regularly. This will also permit him to improve the genetic characteristics of his herd at minimal cost.

For any size livestock operation, an area needs to be set aside for restraint of individual animals. This can be a small runway with an area for catching an animal with a snare or nosetongs or a more elaborate chute or catch to provide adequate restraint for close examination and treatment.

It is also very helpful to have an isolation area for sick animals or naimals about to give birth. This area should be situated apart from other livestock and yet convenient to allow for frequent observation. High levels of sanitation should also be maintained throughout the livestock operation as an aid in controlling disease.

The need for adequate ventilation cannot be emphasized enough in the design or construction of indoor housing for animals. Respiratory diseases are a year round problem for many producers. Even in very cold areas, our common livestock species will do better in well ventilated housing than in warmer closed in facilities.

ZOONOTIC DISEASES

Animal diseases that can be transmitted to man are called zoonotic diseases. Special safeguards should be taken to be certain that animals raised on small farms pose no disease risk to man. Good management and sanitation practices will prevent the occurrence or transmission of most of these diseases.

Unpasteurized milk may carry a number of disease organisms. Many small farms still utilize a family cow for their milk supply and owners should consider pasteurization. Home units for milk pasteurization provide protection from a number of these pathogens found in raw milk.

Human infections of brucellosis and bovine tuberculosis, once very common zoonotic diseases in this country, are uncommon in the United States today. There has been a marked decline in these animal diseases due to State and Federal eradication programs and to an increased public awareness of the risks of these diseases. An owner can protect his herd from these diseases by requiring that animals added to the herd be test negative and isolated and retested. These diseases may be transmitted by drinking unpasteurized milk or by handling infected animal tissues.

In localized areas where anthrax is endemic, routine cattle vaccination in encouraged by veterinary and public health officials, just as rabies vaccination is encouraged for the canine population. Leptospirosis vaccination in cattle and swine is important in some areas as an aid in preventing this common zoonotic disease.

It is important that owners of small farms discuss potential zoonotic diseases that might affect their livestock with their veterinarian and local Extension Office and take any precautions recommended. Livestock producers need to be aware of the dangers of such diseases in order to prevent disease introduction and transmission.

Should a person working with livestock develop an undiagnosed illness, it is worthwhile to alert the attending physician of the possibility of the presence of a zoonotic disease. Many of the zoonotic diseases have been reduced to such a degree in the United States that they may go unrecognized in man when they do develop.

BUYING AND SELLING LIVESTOCK

Many factors must be considered when buying livestock: breed, age, intended use, current and anticipated market conditions, etc. One factor, however, transcends all of these and that is the health of the animals involved. There is no 100 percent sure way to avoid disease, but there are things the buyers can do to minimize the possibility of serious loss.

Whenever possible, purchases should be made directly from a local herd with which the buyer is familiar. When buying from a market or dealer, the buyers should make sure they are reputable and not itinerant livestock peddlers or those offering a "good deal."

Regardless of the origin of the animal, the buyer should insist on health certificates that clearly identify the animals purchased. Vaccination records should be examined where applicable and testing records reviewed. The buyer should remember that this is the time to protect his investment and avoid many costly health problems in the future.

The small farm owner may also be involved in selling livestock for the purposes of slaughter, production, or as breeding animals. Investment return and continued profit will depend upon the sale of healthy animals. Owners selling diseased livestock are also being held accountable by the courts, and judgment against unscrupulous sellers are not uncommon.

The owner or operator of a small farm should consider State and Federal health requirements when marketing his livestock. Federal, State, and local animal health regulations may be obtained from appropriate officials or from a local veterinarian accredited by the USDA. These regulations are in effect to prevent the movement and sale of diseased animals and should be strictly followed. Owners who do not knowingly sell diseased animals and who comply with all State and Federal testing and health requirements are acting in good faith and have little need for concern in these transactions.

A small farm owner may be interested in raising good breeding stock for sale and may want to investigate our current foreign export market as well as markets in the United States. The United States exports a large number of livestock each year, and the rewards can be both satisfying and profitable. Often the destination countries require that a number of specific health requirements be met prior to leaving the United States. There are excellent opportunities for the small farm producer to meet the detailed livestock herd history, testing, and isolation requirements necessary for exportation. Breed associations can be very helpful in providing information regarding livestock export.

A small farm owner who sells cattle to buyers in other States or countries, may want to investigate procedures for officially certifying his herd as free of brucellosis and tuberculosis. Swine herds can be validated free of brucellosis as well. Participation in such a program enables the livestock owner to be confident of his test status for these diseases and is an aid to exhibiting and selling animals.

It has been the intent of this paper to discuss veterinary and health issues confronting small farms. The tremendous diversity of livestock operations on small farms in the United States makes it impossible to describe specific animal health problems within this context. Problems include infectious diseases, internal and external parasites, nutritional diseases, genetic deficiencies, toxins from feed and environment, and metabolic disorders often arising from increased production. All of these problems confront the small farm livestock owner. Many of these problems can be prevented or controlled by proper management and by the best utilization of animal health resources in the community. The small farm livestock operation can be productive and satisfying, but consideration of animal health is critical to the success of such an operation.

The utilization of a private veterinary practitioner has been stressed. The small farm owner should maintain contact with a local veterinarian and discuss with him the use of his services on the farm. Often the veterinarian will encourage the small farm owner to be involved as much as possible in the maintenance of livestock health on the farm. Preventive measures and disease control efforts can frequently be carried out by the owner. When and how much to use the veterinarian should be assessed by the owner and the practitioner in terms of the type and extent of the livestock operation and the extent of the health problems on the farm. The local veterinarian can discuss management practices and many aspects of livestock production that will assist the owner in maintaining animal health.

The small farm owner must be continually alert to the threat of livestock disease and manage for prevention and control. This paper has attempted to point out the large number of resources available to the owner of a small farm in terms of animal health and some management considerations in promoting healthy livestock production.

FACILITIES AND EQUIPMENT FOR SMALL-SCALE FORAGE-LIVESTOCK PRODUCTION

William L. Kjelgaard [1]

ABSTRACT

Fencing is a major need of small-scale livestock producers. High-tensile fence designs from New Zealand, combined with new materials and proper construction meets the general requirements for strength, reliability, durability, productivity, and cost. This fence design depends upon strong end and corner post construction. Strength test results indicate that end posts (5-6 in diameter, 3.5 foot depth) with one brace post, horizontal brace, and diagonal brace wire, will in firm well-drained soil support a 10 wire high-tensile fence. Wet soil, inadequate post depth, or tight angle corners will require two brace posts with horizontal braces. Electric fence designs generally lack physical strength to turn excited livestock. For sheep electric fences require rigid, unyielding design for wool penetration and good contact. A bottom electric wire height of 6-7 inches required frequent maintenance for weed control.

A plastic lined swimming pool performed satisfactorily for on-site water supply for summer pasture. When insulated on sides and top and equipped with wind-powered agitation, the water was ice free over winter. Designs for wintertime livestock watering facilities including feeding racks for round bales are being tested.

Much engineering research and development is needed before small-scale livestock producers will have the machines, equipment, and facilities for convenient, energy efficient, and productive enterprises.

Keywords: Engineering, fence design, research needs, small farms, small livestock farms.

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INTRODUCTION

The machines, structures, and layout for small-scale livestock farms represent essential engineering components for such an enterprise. These technologies have fallen behind the times due to the lack of engineering research and development. Wittwer, from Michigan State University, in discussing mechanization technologies for U.S. farms says "At least 50% of the farms are in the 'small' category. Most such farms are now using outdated, second hand, and fossil-energy-intensive equipment (5)." Private industries doubt the market size for recovery of developmental investments, so they are reluctant to become involved. Public institutions channel their engineering research elsewhere. A regional report on research needs for beef cattle in 1973 allocated .3% of all public institution beef research to mechanization and structures (2). At that time the Southern Region, which included Oklahoma and Texas, indicated no public institution beef cattle research for mechanization and structures. This general situation also applies to engineering research and development for sheep production. The lack of engineering input means that the small livestock enterprise, in partilar, is likely to be supported by physical technologies which are out-of-date and deficient in the utilization of modern materials and concepts. The demand for energy efficient and labor-saving livestock systems, whether large or small, requires skillful designs for machines and structures which spring from innovative ideas tried and tested by engineering research. When such research is missing, progress is delayed because an important requirement of the system is being neglected.

PHYSICAL REQUIREMENTS FOR SMALL-SCALE LIVESTOCK FARMS

For small-scale farms physical inputs of land, machines, energy and labor are constrained by economic factors and available time. To some extent these input elements can be substituted one for another. More machines and energy may reduce labor or substitute for more land, such as intensified farming. Structure design and facility layout may also influence energy, labor, and machine inputs. The reliability and trustworthiness of the enterprise strongly relates to the design and quality of its physical elements. Each individual livestock farm is not altogether unique. Many physical components of livestock farming are common and designs transferable from one to another simply by scaling up or down. Scaling down doesn't mean that specifications and performances are less rigorous. More often scaling down sharpens demands for performance and reliability because of part-time availability of time and labor. Some structural and machine designs have lower scale limits which are above small-scale concepts, and therefore not readily adaptable, in present form, to small-scale use. Silos for feed storage are an example of one such structure. Farm tractors, on the other hand, are broadly scaled with designs suitable for operations of different sizes, often with comparable performance and efficiency. All of this means that small-scale livestock sysems will not be scaled down replicas of large systems. Some physical elements will be common and others uniquely and specifically different. Determining the physical requirements that are different and proposing and testing possible alternatives is an area for engineering research.

FACILITIES AND EQUIPMENT

Fencing

Fencing is a common structure among livestock enterprises especially small-scale. Fence designs must be 100 percent dependable, durable, low maintenance, easy and productive to build and of reasonable cost. Large livestock operations with confined housing and feed-lots do minimum fencing. For small-scale livestock farmers fencing is their major structural undertaking.

Fence research in the U.S. has been at a low activity level in recent years. According to CRIS reports (3) fencing research was primarily involved with excluding predatory animals rather than containing livestock. A multiple strand smooth wire suspension fence designed and tested in New Zealand represents the most up-to-date fencing technology for livestock. American manufacturers and suppliers now provide materials for this fence design. Individually strung smooth galvanized wires of high tensile strength are vertically spaced but not firmly secured to pressure treated wood posts. Ten wires are used for livestock fences. On level terrain post spacing may range to 40-60 ft. with "droppers" as wire spacers and stabilizers every 10 to 20 ft. in between. Each wire is tensioned individually with a ratchet device to a minimum of 250 lb. End posts and corner posts resist the tension load. This fence design requires strong end and corner assemblies usually of 8 ft. posts 5 to 6 in. minimum diameter and up to two brace posts with horizontal braces and diagonal brace wires. Long straight runs with as few end and corner assemblies as possible are the most economical and productive designs for this type suspension fence. Properly installed, high-tensile fence will last for 1 generation or more with low maintenance. The 10 wire design makes a reliable perimeter fence for sheep or cattle at a materials and labor cost 1/2 that of comparable woven wire and about the same as 5 strands of barb wire with similar end and corner post designs (4). At Penn State agricultural engineers determined the contribution of fence post end assembly design to holding strength (7). Single end posts, end posts with one brace post and horizontal brace and diagonal wire (single panel) and end post with two brace posts and horizontal braces (double panel) were tested (Fig. 1). All post and braces were 8 ft. length. Posts were driven into auger-bored holes to a depth of 3.5 to 4 ft. End post assemblies were constructed in accordance with ASAE Engineering Practice Standard EP250.2 (1) and How to Build Fences (4). Each assembly was duplicated for replicated tests. Soil type was well-drained silty clay loam at moderate moisture content.

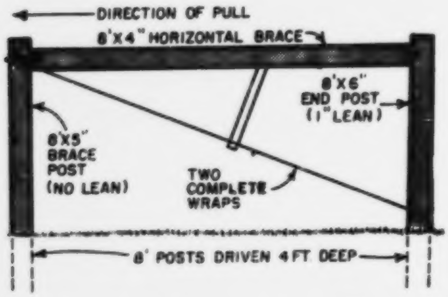

Figure 1. Single Brace Panel, Wood Posts (from USS How to Build Fences)

A steady horizontal pull was applied to the end post 4 ft. above the ground surface by a cable and anchored hydraulic cylinder. End post deflection was measured. When deflection reached 5 inches the test terminated. Generally the soil yielded at the post base allowing over-turning. In these tests the soil strength was the limiting factor. The wood posts had reserve strength at the time over-turning failure occurred. Table 1 indicates the relative strength of end post designs where post deflection was 2 in., at 4 ft above the ground, which was considered within the elastic recovery of the design resulting in no permanent damage or repair need. This condition was considered maximum working load (Table 1). Over-turn failure occurred at 5 in. deflection and resulted in permanent damage.

Table 1.--Tension Load on Fence Post Assemblies[1]

End Post Design	Working Load (lb)	Over-Turn (lb)
Corner post (unbraced)	1150	1950
Corner post, w/brace post and horizontal brace	3200	5200
Corner post, w/2 brace posts and horizontal braces	4750	9100

[1] From Kislan (1981)

These data (Table 1) indicate a working load strength increase of 2.8 for a horizontally braced assembly with one brace post over unbraced single posts. Double brace posts further increased working load strength. Assuming a 10 wire fence with each wire tensioned to 500 lb. and uniformly distributed, it would require a working load of 2000 lb. in equivalent terms to Table 1. This requirement exceeds the strength of a single post under the test conditions but is somewhat under the single brace post assembly for a margin of safety.

Electric fences work best as internal division fences for pasture management or supplemental to perimeter fences for greater reliability or predator control. For sheep, a 4-wire electric fence of 30 in. height and rigid unyielding construction appeared to be satisfactory. The rigid property helped to penetrate wool as sheep pressed against the fence. This established good electrical circuits for shock delivery. The recommended location of the bottom electric wire for sheep fencing was 6 in. above the ground surface. Close enough to have problems with weeds and other vegetation causing reduced power and short circuits. As the result, weed control measures were needed. Electric fencing for cattle is less demanding. Often a single wire at 30 in. height suspended at spacings of 50 to 60 ft. will be effective for grazing management under tranquil conditions. If cattle are excited, such a fence lacks physical strength for containment. The performance and reliability of electric fence energizers has improved with the use of solid-state electronics. Battery powered energizers with solar-cell recharging units have performed satisfactorily. On a 12 volt system a solar charger output 5 times the average energizer requirement maintained a charged battery over an entire summer pasture season. During the winter the battery charge weakened. Overall, there is renewed farm interest in fence building and new material and designs are proving effective, durable, and very competive in cost.

Water Facilities

Providing good quality water year-round is often a problem for small-scale livestock producers. Installing and maintaining water systems for ice free operation during winter months in Northern Regions can be expensive. On pastures where water availability may be temporary or in limited quantity, a plastic swimming pool can be used as a holding reservoir. When equipped with 6 in. of rigid insulation and wind-powered agitation, the water in the pool may remain ice-free during winter. Wind power may also be used for pumping into another holding tank at higher elevation for gravity distribution. Experiments at Penn State with an insulated above ground swimming pool 18 ft. diameter equipped with wind-powered agitation, produced ice-free conditions over winter when temperatures sometimes dropped below 10^{o}F overnight (8). The research determined that agitation induced water flow across the bottom of the pool in contact with warmer soil transferred sufficient heat to prevent freezing. In this experiment the

18 ft. diameter pool was covered with a floating insulated cap. Later this pool was relocated to provide water for approximately 100 sheep during the pasture season. A 5000 gallon capacity was more than adequate for the season under central Pennsylvania conditions.

Ice-free winter water for sheep was obtained by building a box around an insulated 30 gallon drum with an access opening. This unit was equipped with a thermostat controlled 65 W electric heating tape. Performance was satisfactory. Power use was 25 kWh per month during January and February. This unit did not have automatic refilling.

There needs to be location flexibility in water system designs for livestock and continued testing of materials and designs for economic, reliable and energy efficient watering facilities.

Shelter and Feeding Facilities

Basic specifications in this area should be mimimum size, efficient and easily managed, low maintenance and cost. If housing facilities are portable, they can be relocated for more convenient clean-up; more uniform distribution of manure and traffic and greater flexibility of use. For small-scale livestock production, shelters are unnecessary in many regions. Some facilities for minimum shelter during critical periods, such as lambing, may be desirable.

Designs for livestock shelters and feeding facilities which incorporate modern materials and construction methods should be undertaken and tested for small-scale farmers. Their needs in this area can be quite different from large-scale systems.

Feeding rack design for round hay bales for both cattle and sheep have been under investigation at Penn State. Also, shelters for sheep which involve many of the above principles have been built; testing is continuing. No one design has yet been selected for recommended use.

Power and Field Equipment for Small-Scale Farms

Planting, harvesting, and transport functions associated with small-scale livestock production are now mechanized. Used farm machines not specifically desiged for, but adapted to small-scale are being used. These machines do not develop full energy efficiency in small-scale use and can be costly to maintain and repair. Sometimes the used machine's size dictates tractor power beyond the average need for the enterprise. If this happens, it diminshes fuel efficiency and increases costs.

The Japanese have successfully developed small-scale machine systems suited to small farms (6). They are now exporting small-scale farming machines and technology to other countries. In Japan small-scale crop production dominates agricultural activities and represents the primary farm machinery market. In the U.S. the small-scale livestock producers have a less demanding and more variable machine need than crop producers in Japan. This variable status of machine uses makes it difficult to determine exactly what the needs are and more importantly reflects a "soft" and high risk market for equipment manufacturers. Before industry will design, test, and market machines specifically intended for small-scale livestock farms, they, the small-scale livestock farmers must settle on technical practices requiring machine inputs which indicate a general pattern of uniformity. Perhaps this pattern now prevails and it is a matter of making others aware of its existence. To some degree, the machine problem for small-scale livestock farmers reflects their strong independence and unwillingness to to admit that they do indeed have machine needs. Lack of cooperation among such farmers to agree and define the machine related technologies vital to their enterprises diminishes their impact for new equipment development. These attitudes will in fact, need to be changed before unique mechanization progress will occur for small-scale livestock producers.

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PRODUCTION INPUT OPTIONS IN FORAGE-LIVESTOCK ENTERPRISES

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ABSTRACT

Present-day knowledge and technology allow managers many choices in developing forage-livestock enterprises. However, owing to the very large number of interacting factors, decision making often is difficult. In this paper options available to producers are dealt with in two categories, forage crops and animal production. Obviously, the two must be integrated in any successful system. Therefore, attention is also given to matching feed supplies and animal requirements. Owing to recent advances in energy costs, many of the more attractive options deal with means of reducing energy inputs. To the extent that family labor is available and can work in forage/livestock production, uses of fossil energy and expensive machinery can often be reduced.

Many decisions have to be made in forage-crops production. These include choice of plants, seeding times and methods, and means of controlling competing vegetation. Changing seasonal growth patterns of the plants, improving forage quality, and harvesting and storing forages for winter feeding are other areas which allow the producer opportunities for development of a feed production system designed to fit individual needs.

Options in animal production provide choice of the particular kind of enterprise or species of animal. Some enterprises, beef and sheep for example, offer several kinds of production opportunities within each.

Substitutions of feedstuffs permit use of high-quality forages, especially legumes, to replace considerable amounts of grains and protein supplements in dairy rations. Appropriate grazing management can reduce grain requirements of dairy cows, or give higher daily gains of nursing beef calves and lambs, resulting in heavier animals at weaning and/or marketing. Mixed grazing of two or more animal species may result in improved efficiency of plant utilization, especially where a wide variety of plants is present.

Finally, good managers have the opportunity of modifying both their plant (feed) production programs and animal enterprises and management to effect improved efficiency. Seasonal growth of pastures can be altered to some extent, and time of livestock breeding can be modified considerably. Thus, with appropriate management the two can be changed, helping to insure that feed supply and quality are greatest at the time of highest animal needs.

Keywords: Beef cattle, dairy cattle, feed supplies, forages, grazing, legumes, pastures, sheep, small farms, part-time farming.

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Advances in agricultural productivity in the U.S. since WW II have resulted, largely, from use of increasing amounts of fossil energy and sophisticated machinery. To the extent that family labor is available and can work in agricultural production, use of fossil energy and expensive machinery can often be reduced.

Successful production of livestock, based primarily on forages as the feed source, is one of the most complex agricultural enterprises. A large number of factors, including soils, plants, weather, pests, and the livestock, continually interact. Therefore, decision making is often difficult.

Present-day knowledge and technology allow managers many choices in development of forage-livestock programs. New research findings continually add to the store of available knowledge, and astute observers increase their skills as they gain experience. Only a few examples of the kinds of choices open to forage-livestock producers can be dealt with in this presentation. Some management guidelines for part-time farmers were given by Brockett (6).

FORAGE-CROP OPTIONS

Establishment

Choosing Kinds of Plants

A few hundred species of plants are widely used as forages for livestock feeding. Each has its own unique characteristics and environmental requirements for growth. Choice of plants is, therefore, a very important decision in forage/livestock farming. Special attention should be given to use of high-quality seed of varieties and species known to be well adapted to the producer's needs and conditions. Pastures and meadows are often expected to last for long periods of time, and normally the additional cost of high-quality seed of the best-adapted types is returned during early life of the stand.

Most forage plants belong to either the grass or legume families of plants. These two families are more important in forage-livestock production than are all others combined. Grasses and legumes differ in many fundamental aspects of their morphology, growth requirements, and chemical composition. For pasture purposes, grasses provide a source of feed and, also, basic soil binding and weight-bearing properties required with grazing animals. Legumes provide, generally, higher quality feed than do grasses (26) and, owing to their ability when nodulated to utilize (fix) atmospheric nitrogen, do not require applications of commercial nitrogen fertilizers. Grasses, in contrast, are dependent for most of their nitrogen on the supply made available from the soil, and without additions of commercial nitrogen fertilizers are quite low yielding. Pure swards of cool-season grasses without nitrogen fertilization normally yield only approximately 1,000 to 2,500 pounds of dry matter per acre annually (8,27).

With nitrogen application, yield responses of 15 to 30 pounds of dry grass for each pound of applied nitrogen are common with the cool-season grasses (25). Warm-season grasses, although generally of lower quality than cool-season ones, may produce 50 or more pounds of dry forage for each pound of nitrogen used (23).

Nitrogen currently costs approximately $0.30 per pound in solid-form fertilizers. Legumes, owing to their ability to fix nitrogen directly from the atmosphere, can replace appreciable amounts of nitrogen fertilizer in forage production. In a trial at University Park, Pa., three legumes, alfalfa, Medicago sativa L., red clover, Trifolium pratense L., and birdsfoot trefoil, Lotus corniculatus L., were seeded at different rates alone and with either orchardgrass, Dactylis glomerata L., or perennial ryegrass, Lolium perenne L. (22). The grasses were also seeded alone and fertilized with varying amounts of nitrogen (0 to 400 pounds per acre per year). Yields of the grasses with different amounts of nitrogen fertilizer and with each of the legumes for the first four harvests after seeding are presented in table 1.

Table 1.--Total Yields of Dry Forage Produced by Two Grasses Seeded Alone and Receiving Different Levels of Nitrogen or Seeded with Three Legumes (tons/acre)

Nitrogen Used (lb/A) or Legume Seeded	Orchardgrass	Perennial Ryegrass
None	2.1	2.0
100	4.1	3.6
200	6.6	5.5
300	7.0	6.5
400	7.6	6.8
Alfalfa	6.0	6.5
Red Clover	4.8	5.3
Birdsfoot Trefoil	4.5	4.6

With increasing costs of nitrogen fertilizer, the role of legumes in forage-livestock enterprises is being reassessed virtually worldwide. The most important factor in exploitation of legumes in animal production is to focus attention on growth requirements of the particular legume(s) to be grown, so that a favorable environment for its establishment, growth, and persistence can be created and maintained. Relative advantages and disadvantages of grass/nitrogen fertilizer programs and of grass/legume mixtures and management suggestions for each have been published (25).

Seeding

During the course of several centuries, plowing and fitting of the soil for seeding and establishment of crops were considered necessities. It is now well known that many crops can be successfully established under a wide range of conditions with little or no tillage. Good livestock farmers have appreciated for a long time that many forage crops can be successfully established from broadcast seedings on top of the soil into small grains such as wheat or oats. Much less well known is the fact that in humid areas overseeding of legumes into impoverished pastures and meadows can, with proper management, result in successful stands and lead to marked improvement in forage production and quality. Use of this practice makes it possible to improve small-farm pastures and meadows without use of sophisticated seeders and tractors.

A trial was conducted in Pennsylvania to evaluate seeding methods. Plots were broadcast seeded by hand (April 4, 1979) or drill-seeded (May 7, 1979) with alfalfa, red clover, or birdsfoot trefoil into an old orchardgrass-Kentucky bluegrass, Poa pratensis L., sod. The area was limed and fertilized with phosphorus and potassium, based on a soil test, prior to seeding. Glyphosate herbicide (1.5 lb/A, a.i.) was applied in bands to half the drill-seeded plots, and carbofuran 10G (5.6 lb/A, a.i.) was used on all plots to control insects. Grass was cut just above the legume seedlings in broadcast-seeded plots and removed April 30, and in all no-herbicide plots May 16. All plots were harvested three times in 1979 and once in 1980. Table 2 shows total herbage harvested September 5, 1979, after legume establishment, and on June 19, 1980.

Without herbicide dry matter yields from broadcasting and drill seeding were similar. Early broadcast seeding of alfalfa resulted in a higher proportion of legume herbage than did the later drill seeding without herbicide usage. Red clover in the trial was badly damaged by woodchucks, Marmota monax; otherwise, yields of that legume would have been considerably higher. Drill seeding and herbicide application increased yields of trefoil.

Production

Controlling Competing Vegetation

With availability of selective herbicides, weed control in many field crops is now effected without tillage. In some situations, herbicides have a place in establishing forage crops. However, their use in many circumstances may not be economically justified. There appears to be wide misunderstanding of the real significance of "weeds" in forage/livestock production.

Some so-called weeds have nutritive characteristics which compare favorably with those of the common forage species (4,9). Moreover, acceptability to livestock of many kinds of weeds is sufficiently high that they should not suffer from discrimination (18). Buckhorn plantain, Plantago lanceolata L., a common lawn and pasture weed, is recommended for inclusion in seed mixtures for horse pastures in England (5).

Table 2.--Dry Matter Production and Estimated Proportion of Legume Herbage Following Seeding of Three Legumes by Three Methods (Jefferson County, Pa.)

Seeded Legume	Seeding Method	Dry Matter, lb/A	Legume Herbage, %
Alfalfa	Drilled + herbicide	5,890	32
	Drilled, no herbicide	5,100	19
	Broadcast, no herbicide	5,790	38
Red Clover	Drilled + herbicide	6,930	48
	Drilled, no herbicide	5,380	49
	Broadcast, no herbicide	5,850	43
Birdsfoot Trefoil	Drilled + herbicide	7,090	32
	Drilled, no herbicide	5,150	21
	Broadcast, no herbicide	5,360	23

Growth of weedy plants can be greatly reduced through choice of forage-crop species and appropriate management. In old Kentucky bluegrass pastures in central U.S., for example, nimblewill (Muhlenbergia sp.) is a troublesome, unpalatable, weedy grass. In Kentucky, overseeding of either alfalfa or red clover into an old bluegrass sward proved effective in reducing the proportion of the weed in harvested forage, as shown in table 3 (T. H. Taylor. personal communication).

Table 3.--Proportions of Nimblewill in a Kentucky Bluegrass Sward and in Legume-overseeded Swards

	% Nimblewill in Herbage		
	Establishment Year		Second Year
Treatment	July 15	August 25	September 5
None	22	22	32
Red Clover	6	5	1.5
Alfalfa	14	8	2.5

Sollenberger (22), in Pennsylvania, seeded orchardgrass, perennial ryegrass, alfalfa, red clover, and birdsfoot trefoil alone and in combinations of one grass with one legume, using various seeding rates of the legumes. Table 4 shows the percentage of weeds during the first growing season, which was drier than normal. The mixtures were less weedy than pure-grass swards and, with each legume, the addition of grass reduced weediness.

Table 4.--Percentage of Weeds in Herbage of Spring Seedings During First Growing Season

Forage Crops	Weeds, %
Grasses alone, no nitrogen fertilizer	76
Alfalfa alone	61
Alfalfa with grass	51
Red clover alone	72
Red clover with grass	52
Birdsfoot trefoil alone	79
Birdsfoot trefoil with grass	66

Changing Seasonal Growth Patterns

Cool-season grasses are most productive during spring and fall, if soil moisture is adequate. Warm-season grasses, on the other hand, are higher yielding during summer. With cow/calf and ewe/lamb grazing programs, feed requirements normally increase from spring to fall, or until the young are sold.

Where they are adapted, use of both cool-season and warm-season grasses for beef cattle and sheep production will result in a more uniform supply of pasturage during the growing season. Also, legumes such as alfalfa, red clover, white clover, T. repens L., and birdsfoot trefoil can be grown with cool-season grasses to increase summer production.

Cool-season grasses grown alone will be ready for grazing 10 to 15 days earlier when fertilized in late winter with nitrogen than will unfertilized pastures. Likewise, fall growth of cool-season grasses can be markedly increased in humid areas through late-summer application of nitrogen (24).

Combined use of pure-grass pastures, fertilized with nitrogen, and of grass-legume mixtures in other fields can provide continuing, relatively uniform grazing from very early spring into winter. In this manner, stored feed requirements are minimized. Nitrogen fertilizers should normally not be used on grass-legume mixtures, as yield responses are minimal and the proportion of legumes is likely to be drastically reduced (25).

Improving Forage Quality

One input option readily available to farmers through time of harvesting, grazing management, and choice of plants is improvement of the quality of forages fed to animals. Reid (20) suggested that Holstein cows could produce more than 11,000 pounds of milk annually on an all-forage diet containing 60 to 65% digestible dry matter. Potential milk yields could be raised to nearly 18,000 pounds by increasing forage digestibility to 70% and attaining an intake of 3.3% of body weight.

Time of grazing or cutting is the most important single factor influencing forage quality. Young, highly digestible herbages are far more valuable than are more mature forages, especially for young, growing animals, lactating animals, and fattening lambs and cattle.

Use of legumes, alone or in mixture with grass, offers great opportunities for improving forage quality and animal performance. Based on results of several grazing and feeding trials, Thomson (26) concluded that sheep grew 25% faster and cattle 20% faster on legume-grass mixtures than on grass alone. In a North Carolina trial (7), nursing beef calves grazing tall fescue-clover mixtures gained 63 pounds per head more than those on pure tall fescue, and in Indiana (21) mixed fescue-clover pastures resulted in 0.50 pound more daily gain per calf.

Harvesting Forage for Winter Feeding

Conserving quality forage for winter feeding is a major problem for small-scale livestock producers in much of the U.S. Haymaking is the predominant current practice, although feed quality and quantity losses owing to rain damage and late harvesting are often severe.

Time and labor restraints have prompted many small farmers to consider large hay packages (stacks, round bales) as a means of harvesting and storing forage for winter feeding. However, in relation to conventional hay systems, storage and feeding losses are often higher. Wilson et al. (30) concluded that approximately 25% more hay is needed to maintain the same number of beef cows with outside-stored round bales than with barn-stored rectangular bales. However, Baxter et al. (1) found that dry matter losses were only 3.4% when large round bales were stored indoors.

Alternatives to haymaking, such as production of silage, may result in preservation of a greater percentage of the standing-crop nutrients for feeding. Waldo and Jorgensen (28) give the following estimates of the percentage of dry matter in the standing crop which is available for feeding post-storage: field-cured hay, 76%; barn-dried hay, 84%; untreated direct-cut silage, 80%; formic acid treated direct-cut silage, 85%; wilted silage, 68%. However, many small farmers are not equipped for silage systems.

In addition to storage losses, labor and energy considerations are of considerable concern to the livestock producer. Kjelgaard (17) summarized these requirements for various forage systems (table 5). Clearly, labor and fuel requirements tend to vary inversely for the various systems.

Table 5.--Labor and Fuel Requirements from Field to Feeding per Ton of Dry Matter Available and Acceptable as Feed

System	Man hours/T of dry matter	Fuel/T of dry matter, gal
Silages, tower silos, unloaders, and feed bunk	1.0	2.1
Silages, horizontal silos, self-unload wagons, and feed bunk	0.8	1.7
Regular hay bales, indoor storage, and manually loaded self-feeding rack	2.0	0.7
Round bales, outdoor storage (6 mo.), bale mover, and fence-line feeder	1.6	1.4
Hay stacks, outdoor storage (6 mo.), stack mover, and fence-line feeder	1.8	1.6

ANIMAL-PRODUCTION OPTIONS

Choice of Enterprise

A large number of animal enterprises are available, and careful consideration must be given to many factors, including available land resources and capital, buildings and equipment, markets, labor supply and requirements, and personal preferences.

Dairying

Production input options in a forage/dairy enterprise are well exemplified by substitutions which can be made in feed supplies. High producing dairy cows require excellent nutrition, including high levels of energy, crude protein, and minerals. High-quality forage crops such as corn silage, alfalfa haylage and silage, and well-managed pastures can supply very large proportions of the animals' requirements. Data of Hibbs and Conrad (13) showed that high-protein alfalfa could replace grain and protein supplement in rations for lactating cows producing approximately 18,000 pounds of milk per lactation.

In a Pennsylvania study (10) with lactating Holstein cows, replacement of 20% or 33% of the concentrate ration with ground, bud-stage alfalfa-grass hay (23% crude protein, 71% in vitro digestible dry matter) caused no changes in milk production or body weight. Thus, some substitution of high-quality forages for concentrates can be made and, depending on relative prices, may be feasible.

For cows at pasture, allowing the highest producing animals access to pasture ahead of lower producers, dry cows, and heifers results in lower grain requirements without unduly sacrificing milk production (2).

Beef

A variety of beef enterprises allows producers much choice in use of resources and time devoted to beef operations. The cow-calf herd, for example, normally utilizes large acreages of land but requires relatively little time per animal unit. Moreover, the inherent plasticity of mature beef brood cows and their calves gives them an advantage, in terms of management requirements, which many other livestock enterprises lack. Feeder calves can be produced successfully from all-forage diets.

Blaser et al. (3) outlined a number of operating principles applicable to cow-calf enterprises. Double stocking of pastures in spring, when plant growth rates are highest, with hay being made from ungrazed areas helps insure a high degree of feed utilization. Creep grazing of calves, allowing them access to forage of higher nutritive value than that provided their dams, promotes higher daily gains and heavier market weights. Creep feeding of corn or other high-energy rations to nursing calves on pasture may or may not be economical, depending on pasture conditions and relative prices of feed and calves at market.

Sheep

Ewe flocks for lamb and wool production were once a common sight on farms of much of the country. Today, sheep numbers are only a fraction of what they were earlier. However, there is considerable evidence of increasing interest in sheep in northeastern U.S., the region where most lamb is consumed. Ewe/lamb flocks provide an excellent means of utilizing rough, hill lands unsuited for production of grain, as sheep can be successfully maintained and produced on all-forage diets or with minimal concentrate feedstuffs.

There are several different kinds of sheep-production programs from which to choose. Reproduction management techniques allow earlier and more frequent lambing and controlled timing of breeding and lambing (14,15). Land resources, forage and other feed supplies, amount and skill of labor available, and access to markets are important considerations in determining whether to engage in sheep production and, if so, the particular kind of program.

Mixed Species

Grazing of two or more species of animals together may offer certain advantages. Diet preferences of cattle, sheep, and goats, for example, differ somewhat. Goats consume more browse (leaves of shrubs and trees) than do sheep, which utilize more browse than do cattle (29). Devendra (11) discussed the role of sheep and goats in less-developed countries.

Goats are useful in removing brush and, indeed, have been effectively utilized for that purpose. In a grazing trial in progress at The Pennsylvania State University, goats are being grazed with sheep. Their preference for browse of sumac, Rhus sp., and gray dogwood, Cornus sp.; and for brambles, Rubus spp., thistles, Cirsium sp., and goldenrod, Solidago sp., over common grasses and legumes was clearly demonstrated during the 1981 grazing season. Preliminary observations indicate that with the amounts of browse and forbs available there is relatively little overlap in the diets of the sheep and goats. Under such conditions, two or more animal species will more effectively utilize plant resources. Combined grazing of beef cattle and sheep may improve forage utilization. Further, a combination of livestock enterprises may help the small farmer make more efficient use of available labor and capital and provide increased marketing alternatives.

MATCHING FEED SUPPLIES AND ANIMAL REQUIREMENTS

Owing to the restraints to plant production imposed by climatic factors in temperate climates and the ever-changing nutrient needs of domestic herds and flocks, producers are faced with the problem of harmonizing available feed resources with animal requirements. A constant challenge to the livestock producer is provision of the quantity and quality of feed needed to meet the various productive functions of the animal. Production phases of the breeding herd, in order of increasing nutrient requirements, are maintenance, gestation, and lactation. The astute producer will be aware of these phases when designing the feed program.

Successful livestock production, based primarily on forages, requires control of both the plant and animal aspects. Many producers devote too much attention to one or the other, missing opportunities to improve efficiency by virtually neglecting one of the areas. As pointed out earlier, feed production patterns can be changed and forage quality can be altered within wide limits. Likewise, animal enterprises usually can be selected which aid utilization of land, labor, capital, knowledge, and other resources. Within most animal enterprises there is sufficient diversity to allow for considerable latitude in day-to-day practices, capital investment, cash flow, labor requirements, and detailed attention required.

For example, the producer can exercise considerable control in matching feed resources and animal requirements by selection of time of breeding, a primary determinant of the pattern of feed requirements. This is more easily manipulated in cattle than with sheep, although proper breed selection and appropriate management with the latter permits adequate flexibility.

Generally speaking, the cheapest source of nutrients on many small farms is pasture, especially when operator labor and feed harvesting and storing costs are considered. Thus, it is desirable to match pasture availability with the period of greatest nutrient requirements, i.e., lactation. For small farms in the Northeast, this dictates a spring calving or lambing program. Young are born shortly before pasture production and quality are highest, and milk production is stimulated. Unique marketing situations may suggest a fall calving or lambing program, although peak nutritional requirements must be met with more expensive harvested feeds.

A special problem with sheep, which somewhat limits full utilization of pasture, is the extreme seasonal nature of desirable markets. Peak prices for lamb are typically paid just prior to Easter, which is not conducive to pasture-finishing of market animals. This is a situation over which the producer has little direct control at this time. Aggressive efforts are underway to lessen fluctuations in lamb prices. However, producers must do their part in presenting meat packers with a steady, year-around supply of lamb such that their labor and facilities will be efficiently utilized.

RESEARCH NEEDS

The nature of forage/livestock problems calls for interdisciplinary efforts in research. Representatives of all agricultural disciplines, along with personnel from the biological, social, and physical sciences, must be involved.

Computers and simulation studies of the systems and sub-systems offer much promise for pointing up relative needs for research in various areas, in improving understanding of the fundamental nature of interacting parts of overall systems, and in increasing utilization of resources. Forage/livestock research should, to the extent possible, be planned now to answer problems which will be facing producers and consumers in the next century (19). Kerr (16) published results of a survey of extension county agents in northeastern U.S. concerning research needs of small farms, including some aspects of forage-livestock production.

The Northeast Forage Crops Research Program Steering Committee, in its Report No. 2 (12), identified three comprehensive research thrusts. The second is:

> Develop and test forage/animal production systems, with emphasis on part-time and small farms.

Specific research objectives to be emphasized were listed as follows:

> Increase use of legumes in forage-production programs.
>
> Increase production of forage with improved feeding value.
>
> Reduce nutrient losses associated with harvesting, storing, and feeding of forages.
>
> Develop systems to improve efficiency of forage/animal production on land not now effectively utilized because of soil and site limitations.
>
> Develop techniques for introducing perennial forages into existing stands.
>
> Develop animal-production systems based on maximum utilization of grazing.
>
> Evaluate the economic worth of alternative forage/animal production adjustments.
>
> Increase mid-summer forage production.
>
> Develop forage based feeding programs to efficiently produce beef from dairy calves.

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THE CHEMISTRY AND PROCESSING OF GOATS' MILK

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ABSTRACT

The keeping of dairy goats is increasing steadily in the United States. The dairy goat is especially adaptable to a small farm operation with marginal grazing and, if properly managed, can provide some income to the milk producer. Goats' milk is nutritionally equivalent to cows' milk except in its content of vitamin B_{12} and folacin. The major proteins of goats' milk are the β-caseins; α_{s1}-casein, the major casein of cows' milk is absent from goats' milk. The short-chain, free fatty acids (C4:0 - C10:0) play a major role in the "goaty" flavor which is considered desirable in some cheeses but is a defect in fluid milk and other manufactured products. Breed differences, handling practices, and buck odor may also be involved in "goaty" off-flavor development. Major marketing problems are the seasonality of the milk supply and distribution costs. Retail sales average 1 quart per week per 1,000 population; over 70% of urban areas in the United States have no supply of goats' milk. If the dairy goat industry is to grow, there must be well-coordinated marketing plans in addition to current research and development programs aimed at supplying quality goats' milk products to the consumer.

Keywords: goat: milk, milk composition, milk fat, lipids, casein, cheese, yoghurt, UHT-treated, spray-dried, marketing, nutrition, flavor, small farms.

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INTRODUCTION

The dairy goat has never been viewed as a viable economic factor in the United States although its importance in many countries in Europe, the Middle East, India, and Africa is well known. In recent years, a rediscovery of the value of the goat for milk, meat, Angora wool, and even brush control has occurred. The dairy goat is especially adaptable to a small farm operation with marginal grazing, and, if properly managed, can provide a significant income to the farmer.

The increased importance of the dairy goat in the United States may be assessed by the increased membership in goat associations, official shows, and herds on official test. In 1976, the number of registered dairy goats was 32,459, an increase of almost 900% from 1955 (17).

A quality dairy goat gives about 3 or 4 liters of milk daily (17); however, world-wide average milk production is only about 50 kg/doe/lactation, assuming one-third of all goats have milk producing ability (18). Several factors are responsible for the low average productivity, one of which is that few adult females are kept for milk. Among other causes, besides those associated with animal husbandry, is the inability to use the milk to the fullest extent either directly as a beverage or in the manufacture of a spectrum of desirable products.

The purpose of this paper is to discuss briefly research related to the chemistry and processing of goats' milk, especially investigations at the Eastern Regional Research Center (ERRC) concerned with off-flavor and product problems frequently encountered by commercial producers and processors.

Composition

Research relating to the composition of goats' milk has been extensive. Excellent reviews of these publications have been prepared by Jenness (14, 21) and much of the following material was taken from these papers.

The gross compositions of goats' and cows' milk are similar (Table 1) (22). However, breed differences in the fat and solids-not-fat content of goats' milk have been well established by analyzing milk from animals kept under similar feeding regimes and environmental conditions (21). Of the breeds commonly raised in the United States, Nubians produce milk richer in both fat and solids-not-fat than do Saanens and Toggenburgs.

The average fat content of goats' milk is 4.14% (Table 1). In practice, many producers report values below 3.25%, the required minimum fat value for bovine milk in many states (personal communication from Judy Kapture). This means that some producers could have difficulty in meeting compositional standards for the legal sale of goats' milk. In most states, there are no standards for goats' milk, so the standards for cows' milk are applied for regulatory purposes (personal communication from Judy Kapture).

Table 1.—Proximate Composition of Goat and Cow Milks

Components	Goat	Cow
	— Percent—	
Protein	3.56	3.29
Fat	4.14	3.34
Lactose	4.45	4.66
Ash	.82	.72
Total Solids	12.97	12.01

The seasonal character of the supply of goats' milk is partially responsible for the low fat content. Pronounced seasonal variations occur both in the fat and solids-not-fat contents of goats' milk in the temperate zones. Both fat and solids-not-fat reach a minimum in the late summer and increase thereafter (21). The fat content may vary by as much as 2% and the solids-not-fat by 1%. The observed fluctuations in composition probably reflect changes occurring during the course of lactation, since most animals freshen in the early spring. Studies have shown that both fat and solids-not-fat decline to minima about the fourth month of lactation and increase thereafter. This decline corresponds to the seasonal variations and is reportedly greater than similar fluctuations in cows' milk composition (21).

The five major proteins of goats' milk are the whey proteins β-lactoglobulin and α-lactalbumin, and κ-casein, β-casein, and α_{s2}-casein. These caseins appear to be homologous to the corresponding proteins of cows' milk in both composition and properties. The casein of goats' milk appears to lack an electrophoretic component with the mobility of bovine α_{s1}-casein. The α_{s2} fraction of goat casein represents a much smaller proportion of the total casein than the α_{s1} moiety of bovine casein, making the β-caseins quantitatively the major proteins of goats' milk (14). The absence of α_{s1}-casein in goats' milk makes it possible to detect adulteration of goats' milk with cows' milk; it has been reported that as little as 1% of cows' milk may be detected in goats' milk by gel electrophoresis (2).

The carbohydrate fraction of goats' milk has been shown to be primarily the disaccharide lactose (21). It is present in a concentration usually slightly lower than that of cows' milk (Table 1).

Many analyses of the fatty acid composition of goats' milk fat have been reported (14). These are principally the fatty acid compositions of the triglycerides which predominate in the mixture. A comparison of the straight chain fatty acids of goats' milk fat to those of cows' milk fat shows slightly greater levels of C6:0, C8:0, and C14:0 and a considerably elevated level of C10:0 (Table 2) (10).

Some differences in branched chain fatty acids in cow and goats' milk have also been determined (19). The milks of both species contained a series of iso and anteiso monomethyl branched chain fatty

Table 2.—Fatty Acid Composition of Goat and Cow Milk Fat

Fatty Acid	percentage by weight Goat	Cow
$C_{4:0}$	2.6	3.3
$C_{6:0}$	2.9	1.6
$C_{8:0}$	2.7	1.3
$C_{10:0}$	8.4	3.0
$C_{12:0}$	3.3	3.1
$C_{14:0}$	10.3	9.5
$C_{16:0}$	24.6	26.5
$C_{16:1}$	2.2	2.3
$C_{18:0}$	12.5	14.6
$C_{18:1}$	28.5	29.8
$C_{18:2}$	2.2	2.5

acids but goats' milk was found to contain a range of other monomethyl substituted fatty acids, mostly with substitutions on carbons 2, 4, and 6, which were virtually absent from cows' milk. Total monomethyl branched chain fatty acids in goats' milk amounted to 2.02% of the total milk fatty acids.

Work conducted at ERRC over a four month period from July through October, showed the average total lipid content of five bulk goats' milk samples to be 5.0 ± 1.2% (4). The distribution of the lipids among the milk fractions was also determined. The whole milk and cream contained 97 to 99% free lipid and 1 to 3% bound lipid, respectively. Like cows' milk, the free lipid was composed of 97% triglyceride and the bound lipids contained neutral lipid, glycolipid, and phospholipid; compared to cows' milk, however, the skim fraction of goats' milk contained significantly more free lipid. The free lipid was similar in triglyceride composition and fatty acid content to the lipid of whole goats' milk.

The total ash content of goats' milk is slightly higher than that of cows' milk, usually ranging from 0.70 to 0.85% (21). Goats' milk contains approximately 134 mg calcium, 111 mg phosphorus, 50 mg sodium, and 204 mg potassium/100 g (22); 160 to 178 mg chloride/100 ml are also present (14). Although both vary considerably from animal to animal, the contents of potassium and chloride are higher than in cows' milk. A negative correlation between potassium and lactose content for milk of goats and other species has been reported (16); chloride was positively correlated with potassium and negatively with lactose but sodium was not significantly correlated with potassium, chloride, or lactose.

Nutrition

To its proponents, goats' milk has nutritional and therapeutic qualities superior to those of cows' milk. However, there is no clear evidence to support these claims.

Goat, cow, and human milks each supply about 750 kcal/liter; the major difference is in the proportion of calories supplied by the lactose and protein contents. In goats' and cows' milk, fat, protein, and lactose account for about 50, 25, and 25% of the calories respectively; however, in human milk, they furnish 55, 7, and 38% (14). Significantly fewer calories are supplied by the protein in human milk.

Claims have sometimes been made that the fat of goats' milk is more digestible than cows' milk fat. Because the fat globules of goats' milk are smaller in size and have a greater surface area, lipases in the gut supposedly are able to attack the lipids more readily. If this were true, homogenized cows' milk with the bulk of the fat droplets reduced below 2 micrometers in size (7), would be more digestible than unhomogenized milk. It has been reported (26) that no experimental evidence is available to support this claim. However, almost 20% of the fatty acids of goats' milk fall in the C4:0 - C12:0 range of chain length compared to 10-20% for cows' milk; lipases attack the ester linkages of the shorter chain fatty acids more readily so this difference may contribute to more rapid digestion of goats' milk fat (14).

Another question often raised is whether the proteins of goats' milk are digested more readily and their constituent amino acids absorbed more efficiently than those of cows' milk. Although goats' milk and cows' milk differ in proportions and kinds of proteins, the overall amino acid composition is similar (14). The proteins of both milks contain a good balance of essential amino acids, equalling or exceeding the FAO-WHO requirements for each amino acid. Goats' milk does form softer, more friable curds when acidified, but whether this is sufficient to permit more rapid digestion by the stomach proteases remains to be proven (14).

It has frequently been alleged that infants suffering from allergies to cows' milk protein can readily tolerate goats' milk. There is extensive immunological cross-reaction of cows' and goats' milk proteins (24), so many cases of allergy to cows' milk protein would not be benefitted by feeding goats' milk. However, a major protein of cows' milk, α_{s1}-casein, is either entirely absent from goats' milk or is present only in extremely low concentration. It is quite possible that a specific allergy to bovine α_{s1}-casein could occur; such cases should be aided by a diet of goats' milk, but there is no clear-cut experimental evidence at present to support this.

The calcium and phosphate content of milk is one of the most important contributions to the diet; goats' milk and cows' milk contain similar

Table 3.—Vitamin Content of Goats' and Cows' Milk

Vitamin	—amount in 100 g—	
	Goat	Cow
Ascorbic acid	1.29 mg	.94 mg
Thiamin	.048 mg	.038 mg
Riboflavin	.138 mg	.162 mg
Niacin	.277 mg	.084 mg
Pantothenic acid	.310 mg	.314 mg
Pyridoxine (B_6)	.046 mg	.042 mg
Folacin	1 mcg	5 mcg
Vitamin B_{12}	.065 mcg	.357 mcg
Vitamin A	185 IU	126 IU

quantities (22). Milks of both species are deficient in iron, so this important mineral must be supplied by other foods or supplements.

There are many reports of the occurrence of anemia when goats' milk diets are fed (21). An examination of the vitamin content of goats' and cows' milk (Table 3) (22) shows that goats' milk supplies adequate amounts of Vitamin A, niacin, thiamin, riboflavin, and pantothenate, but it is deficient in vitamins C, D, B_{12}, and folacin and may be deficient in pyridoxine (B_6) (14). Goats' and cows' milk are about equally deficient in vitamins C and D so these vitamins must come from other foods or supplements. Cows' milk contains 5 times as much folacin and more vitamin B_{12} than does goats' milk and meets infant nutrition requirements. Although vitamin B_{12} has been implicated in cases of goats' milk anemia, the major cause is lack of adequate folacin, which is necessary for the synthesis of hemoglobin. Several cases of anemia attributed to goats' milk diets have been reported cured by the administration of folic acid (14).

Another difference between cows' and goats' milk is the lack of carotenoid pigments (vitamin A precursors) in the latter. Vitamin A potency of goats' milk is at least as great as that of cows' milk and consists almost entirely of the vitamin itself; all precursors have been entirely converted (21).

"Goaty" Off-Flavor

Historically, fluid goats' milk has a reputation for flavor problems, especially a pronounced lipolytic-type off-flavor usually referred to as "goaty." This may be described best as a rancid or musky odor and flavor that leaves a distinct aftertaste. Although a strong "goaty" flavor may be desirable in some cheeses (1), it is usually rated as a defect in fluid milk.

Considerable disagreement can be found among researchers as to the exact nature and cause of the development of the "goaty" off-flavor. Several factors have been suggested as being responsible: a) improper or unsanitary milk handling and storage; b) contamination of the milk by odorous volatile compounds exuded by the buck; c) breed differences; and d) elevated levels of short chain free fatty acids.

Most researchers agree that the short chain free fatty acids from C4:0 to C10:0 play a major role in the flavor. Bakke et al. (3) reported free fatty acid contents of 5.65 / .58 and 2.67 / .34 meq/l in milks from two lines of goats selected for high and low intensity of "goaty" off-flavor. There was a statistically significant difference; the content of free fatty acids seemed to account for 8 to 12% of the flavor score variation.

Some research at ERRC has been directed toward identifying specific flavor compounds responsible for "goaty" off-flavor in the milk. 4-Methyl octanoic acid has been tentatively identified but has not yet been related to the "goaty" flavor profile. This compound, along with 4-methyl nonanoic acid, has been previously identified as a "goaty" flavor not common to wild goat meat and mutton (27).

Handling practices that could contribute to the development of "goaty" off-flavor include excessive mechanical agitation during milking, temperature fluctuations during cooling and storage, excessive bacterial contamination, and pasteurization or other heat treatment.

Although the lipase activity of goats' milk is only about one-third that of cows' milk (5), spontaneous lipolysis can occur upon cooling fresh goats' milk to 4°C. The rate and extent to which the milk spontaneously develops "goatiness" varies greatly among the milk of individual animals. Excess agitation and foaming during milking can induce lipolysis. "Goaty" off-flavor development may also occur if the milk is cooled, rewarmed to body temperature, and recooled (23).

Bacteria in milk may also produce lipases; high bacteria counts can be related to "goaty" flavor, especially in pasteurized milks stored raw for 7-9 days under refrigeration before being pasteurized (Personal communication from E. J. Guy).

In an experiment aimed at investigating the relationship of lipase activity to "goaty" off-flavor development, raw goats' milk, cows' milk, goats' skimmilk mixed with cows' cream, and cow's skimmilk mixed with goats' cream were homogenized to promote lipase activity. No "goaty" off-flavor was present in the raw goats' milk initially, more was induced by homogenization, although the milks were extremely rancid. Untreated raw goats' milk, held under refrigeration, became very "goaty" upon souring. Examination of the short chain free fatty acid profiles in these milks showed that the sour goats' milk contained a much higher level of C10:0 than did either the rancid goats' milk or the blend of goats' cream and cows' skimmilk (Table 4). Either bacterial lipases were a factor in "goaty" off-flavor development in the soured sample, or that the free fatty acids, present initially as salts, were liberated by acid development.

Pasteurization of the freshly drawn milk will partially inactivate the lipase system and reduce lipolysis. However, in studies with frozen 3:1 and 4:1 goats' milk concentrates, it has been

Table 4.—Free Fatty Acid Profile in Lipase Activated Goat and Cow Milk and Blends (Shorter Chain Acids)

Sample Identification	Relative % of FFA			
	C6:0	C8:0	C10:0	C12:0
Rancid goat	0.9	4.3	13.7	6.9
Goat cream and cow skim	0.7	4.3	13.6	6.8
Rancid cow	1.2	2.5	4.4	4.9
Cow cream and goat skim	-	2.3	6.9	9.3
Sour goat milk	4.4	6.6	23.1	10.1

shown that heat treatment seems to bring about slight increases in "goaty" off-flavor (11).

The odor emitted by a buck during the breeding season has also been implicated as a contributing factor in "goaty" off-flavor. Norwegian investigations indicate that the presence of a buck has no significant influence on the odor or flavor of the goats' milk (25). However, the sebaceous gland responsible for the buck odor is found in does, and, in some does, may become odorous. A "bucky" flavor in milk could be produced by does with active glands.

A portion of the research at ERRC has been concerned with the identification of compounds responsible for the buck odor. Some of these compounds may be sex or territorial pheromones. The major contributor to this aroma has been identified as an aldehyde, 6-trans nonenal, which has a flavor threshold in milk of 0.07 ppb. Traces of the 4, 5, and 7-trans nonenals have also been found. 6-Trans and 6-cis nonenals added to milk give a musky flavor and odor to the milk, but the flavor is different than that identified organoleptically as "goaty" (Personal communication from P. W. Smith).

The identification of the compounds responsible for the flavor and odor of goats' milk could be of value to producers if the concentration of flavor compounds can be controlled. Differences in milk flavor exist between individual animals and between breeds. In a Norwegian study, when comparing Saanen goats imported to Norway with the native Norwegian breed, the Saanens produced milk with a flavor intensity score near to that of cows' milk (1.0) whereas the native goats produced milk with a significantly higher flavor intensity score (3). Negative correlations have been reported between flavor intensity and levels of fat, protein, and lactose in the milk (25).

In a limited experiment conducted at ERRC, milks from three breeds, Toggenberg, Alpine, and Nubian, were assessed organoleptically for intensity of "goaty" off-flavor before and after pasteurization (Table 5). The Nubian milk, with the highest butterfat level, had the lowest level of "goaty" flavor, whereas the Toggenberg milks had the highest levels. Pasteurization increased the intensity of the "goaty" flavor in all cases, especially during storage.

Table 5.—Effect of Breed on "Goaty" Flavor Intensity[1/]

Breed	% BF	Fresh raw	Fresh past.	Aged past.
Toggenberg	3.0	1.8	2.6	3.5
Alpine	3.6	1.7	2.2	2.5
Nubian	4.6	0.7	1.1	1.3

[1/] Intensity scale 0 → 4; higher numbers represent greater intensity.

Other factors are involved in the flavor of goats' milk. For example, the flavor was less pronounced in the milk produced at the start and towards the end of the lactation period, and cheese made from milk produced during the latter stages of lactation had a blander flavor (25). Small differences in flavor were found when comparing milks produced by goats fed on pasture and indoors. Feeding of concentrates generally increased milk flavor, but the method of feeding and different feeds had little influence on the flavor (25).

Manufactured Products

To ensure a year-round supply of goats' milk products, long term preservation is necessary. The manufacture of cheese is one means of preservation; cheese is the only product made from goats' milk that has been studied extensively. There are few available data on the manufacture of fluid goats' milk products such as low fat, fortified, or flavored milks; cultured products such as buttermilk or yoghurt; frozen products, such as ice cream; condensed milk; or dried milk products (18).

The Dairy Technology Group of the University of Georgia conducted a three-year study of processed goats' milk products in cooperation with the Winrock International Livestock Research and Training Center (Morrillton, Arkansas) and Southern Agriculture Corporation. The researchers found that even though the milk had to be collected and held raw at 1-2°C for 5 days before shipping 1046 km for processing, no flavor or processing difficulties were encountered in preparing a 2% fat, protein-fortified (10.5% milk-solids-not-fat) beverage milk (18). The standardized beverage milk could then be used for yoghurt manufacture; 250 bloom gelatin was added to give the desired viscosity (18).

Lowenstein and his co-workers (18) also developed a high quality frozen yoghurt formulation that contained 2.0% milk fat, 10.0% milk-solids-not-fat, 10% sucrose, 10% corn syrup solids (36 dextrose equivalent), and 0.5% soft serve stabilizers. This is the only reported research with frozen yoghurt made from goats' milk. The Georgia researchers also investigated three flavored ice cream mixes. Because goats' milk products cost more than comparable cows' milk products, it was decided that the ice cream must be of premium (a high fat to milk-solids-not-fat ratio) quality to attract the consumer; experience proved this decision to be correct (18).

No Grade A nonfat dry goats' milk is available commercially for standardization, so the milk had to be skimmed and a skimmilk concentrate prepared before the above mentioned products could be processed. Lack of Grade A sources of nonfat dry goats' milk solids will make product manufacture difficult for many small dairies.

The processing parameters leading to physical stability during long term storage of processed goats' milk products are being investigated at ERRC. Good reconstitutability with water into a product with beverage milk characteristics is of prime importance.

One highly attractive method of preserving whole cows' milk is the freezing of 3:1 or 4:1 concentrates. When reconstituted, cows' milk products have a flavor initially indistinguishable from fresh milk. The problem with them has been the tendency to thicken and coagulate during storage, because of crystallization of the lactose which has been brought to its saturation point by the concentration.

Frozen whole goats' milk concentrates with storage stability of up to 10 months were processed by concentrating high-temperature short-time pasteurized goats' milk with 26% or 52% of its lactose in hydrolyzed form to 3:1 or 4:1, post-heating at 71°C for 30 minutes, adding antioxidant, freezing, and storing at -14°C. These concentrates could be thawed and refrozen up to three times without any physical destabilization. It was necessary to add antioxidant to maintain taste quality of stable 3:1 concentrates even during frozen storage (Table 6). The treated samples also developed less oxidized and bitter flavors and less goatiness during the storage period than did the untreated controls (11).

Ultra-high-temperature (UHT) sterilization leading to the production of good tasting shelf-stable fluid milks or milk concentrates that require no refrigeration offers another means of long term preservation of goats' milk. UHT milk processing involves temperatures of 130-150°C and holding times of 1 second or more; 2 to 8 seconds is the usual holding time (20). Although such products have been available in Europe for many years, it is only recently that the U.S. Food and Drug Administration has approved the sterilant for the aseptic packaging material (9).

Evaporated goats' milk is available commercially. Research concerned with this shelf-stable, sterile product was initiated at ERRC when flavor evaluations of the commercial products showed them to be disliked by the panelists, probably because of the presence of "goaty" off-flavor (Table 7).

Table 6.—Effect of Antioxidant on the Hedonic Flavor Ratings[1/] of Milks Reconstituted from 3:1 Concentrates with 26% of the Lactose in Hydrolyzed Form

Storage time (months)	Untreated	Antioxidant (0.01 g/100 g fat)
Initial	5.86	5.86
2	6.25	6.12
4	5.50	5.66
6	5.37	6.00
8	5.42	6.28
10	5.38	5.87

[1/] 9-point scale: 9 = like extremely, 5 = neither like nor dislike, 1 = dislike extremely.

Table 7.—Flavor Evaluation of Commercial Evaporated Goats' Milk

Sample	Age days	Hedonic[1/] rating	Intensity[2/] of goaty flavor
Fresh goats milk	-	6.2	0.4
Evaporated milks			
1	56	2.4	2.1
1A	614	1.3	2.3
2	15	2.3	1.6
2A	184	1.4	2.3

[1/] 9-point scale: 9 = like extremely, 5 = neither like nor dislike, 1 = dislike extremely.

[2/] Intensity scale 0 → 4; higher numbers represent greater intensity.

The storage properties of UHT sterilized whole, pasteurized whole, and pasteurized concentrated (2:1) whole goats' milk, with and without 1% added sodium hexametaphosphate as stabilizer were evaluated. Pasteurization temperature was 124°C for 15 seconds and sterilization temperature was 146.1°C for 4.5 seconds. All samples showed good physical stability initially in terms of in-can sediment and solubility index; however, after 6 months of storage at 25°C, the amount of sediment increased considerably, with greatest increases observed in the stabilized samples (Table 8). Best stability was observed in the unstabilized pasteurized, sterilized milk (8).

Table 8.—Physical Stability of Ultra High Temperature Processed Goats' Milk

Sample	Initial		6 months storage	
	Sediment in can (cm)	Solubility index (ml)	Sediment in can (cm)	Solubility index (ml)
Unstabilized				
Raw sterilized	-	5.5	1.3	5.5
Pasteurized sterilized	-	<.1	0.5	.1
Pasteurized concentrated sterilized	-	1.4	2.0	5.0
Stabilized				
(1% added sodium hexametaphosphate)				
Raw sterilized	-	2.0	2.0	5.0
Pasteurized sterilized	-	<.1	1.4	10.0
Pasteurized concentrated sterilized	-	0.15	2.4 + fat separation	-

Hedonic flavor ratings on a 9-point scale averaged 5 or below initially, reflecting some panel bias against goats' milk. Ratings declined during storage with the greatest decrease observed in the stabilized samples. "Goaty" flavor, judged on a 5-point intensity scale, was slightly greater in unstabilized samples initially and after 6 months of storage, averaged 2.4 compared to 1.9 in stabilized samples (8). Considerable work still remains to be done to solve the flavor problems in this type of product.

Spray dried whole goats' milk powder is available commercially from two suppliers. Organoleptic evaluation of the intensity of the dominant off-flavors found in the two powders after reconstitution showed a difference between them; one powder contained oxidized off-flavor whereas the others were rancid (Table 9). The intensity of "goaty" flavor was about the same in both powders.

Spray dried whole goats' milk powder was prepared at ERRC by heating fresh raw milk for 6 minutes at 76.7°C, cooling to 60°C, homogenizing double stage at 175.8-35.2 kg/cm^2, and condensing to about 45% total solids. The concentrate was standardized to 40% total solids and spray dried at 218.3°C inlet temperatures (13). A slight "goaty" flavor that was present initially remained unchanged during the processing sequence; average hedonic ratings on a 9-point scale improved from 4.12 (raw) to 5.62 (condensed) and declined again to 4.87 (powder).

Hedonic ratings of air-packed samples decreased abruptly after 127 days of storage at 25°C; this decrease correlated with a sharp increase in oxidized flavor criticisms (Table 10). The intensity of "goaty" off-flavor varied only slightly over the storage period (13).

Further evaluation of the processing parameters involved in the preparation of a spray dried goats' milk powder must be carried out if an acceptably flavored product with good shelf life is to be attained.

Cheesemaking has been a cottage industry for centuries with the individual producer using his surplus milk to make small batches of cheese. In the United States, in general, this traditional practice is still followed for goat cheesemaking. Morrison Lowenstein (personal communication) has recently reviewed general cheesemaking procedures for goats' milk so these will not be considered further. More detailed information may be obtained from the University of Georgia, Athens, GA 30601.

At ERRC, a high quality Neufchatel type cheese was made from goats' milk with yoghurt starters, Lactobacillus bulgaricus and Streptococcus thermophilus. Fresh raw whole goats' milk was pasteurized, inoculated with 1% yoghurt starter, fermented to pH 4.6, stirred, heated to 49°C, and cooled to 4.4°C. After the whey was drained from the curd, condiments and salt were added if desired (personal communication from Joseph

Table 9.—Intensity of Dominant Off-flavors in Commercial Goats' Milk Powders[1]

Sample	Goaty	Oxidized	Rancid
Fresh goats milk	.4	.1	0
Goat powder A	1.3	2.2	0
Goat powder B	1.4	.2	.9

[1] Intensity scale 0 → 4; higher numbers represent greater intensity.

Table 10.—Flavor Evaluations of Experimental Powder Stored Six Months at Room Temperature

Storage time (days)	Hedonic rating[1]	Intensity[2] of "goaty" flavor	Intensity[2] oxidized flavor
Initial	4.87	1.6	.25
45	4.90	.9	.5
90	4.20	1.4	.3
127	2.44	1.1	1.1
169	2.62	1.0	1.0

[1] Nine point scale: 9 = like extremely, 5 = neither like nor dislike, 1 = dislike extremely.

[2] Intensity scale 0 → 4; higher numbers represent greater intensity.

Flanagan). Flavor evaluations of the cheese rated it very acceptable.

A processing sequence whereby yoghurt is made on the first day, a Neufchatel type cheese on the second day, and a cheese suitable for ripening on the third day is being developed for use in the home or on the family farm. This information will be available in pamphlet form in the near future.

Marketing

A major marketing problem to the producer is the seasonal nature of the goats' milk supply. Most of the milk comes from individual animals or small herds of a specific breed. The low production volume and the unavailability of small-scale processing equipment limits manipulation of the composition of goats' milk to a specified standard, so wide fluctuations in composition during the year are the norm. This is in contrast to the cows' milk supply where most of the milk consumed comes from pooled milks of different breeds in various stages of lactation. Because breeding practices in cows have shifted away from seasonal breeding, there is a year-round supply of milk that can meet regulatory standards for composition through manipulation of the fat and solids-not-fat contents in the processing plant. Improved feeding and breeding practices with goats have partially alleviated the peaks and valleys in milk production, but problems of supply and demand still exist.

The market for goats' milk is not particularly good. Most commercial operations have concentrated on the health food channel or cheese specialty store. In most states, retail sales from operating dairies average about 1 quart per 1,000 population, with sales of 3 quarts per week per 1,000 being extremely good (15). A good store will sell about 50 quarts of goats' milk per week compared to about 500 gallons per week for cows' milk. Because distribution costs are so high, the milk retails currently at about $1.85 per quart. The best sales occur in areas where there is an unusually favorable climate for buying goats' milk: a strong health-food oriented population, a high proportion of elderly and/or an area where goats' milk has been continuously marketed for many years such as in Arizona, California, and Oregon (15). However, a study of over 200 breeders conducted in 1980 showed that even in California, 58% lost money, 20% broke even, and only 22% made a profit in 1979. None of those surveyed made more than $2500 and 4% lost over $2500 (6). Breeders whose operations were profitable in 1979 had small herds, sold more than 10% of their milk production, were on DHIA test and grew more than 25% of their own feed, thus confirming the importance of careful management.

As of February 1981, 80 goat dairies appeared on state rolls. Sixty-one of these sold fluid milk as their primary product, 17 made cheese, and 2 produced evaporated milk and milk powder. The total volume of goats' milk processed through legal channels each week is estimated at about 30,000 gallons. Over 50% of the supply is processed in two plants located in Turlock, California, and Yellville, Arkansas (personal communication from Judy Kapture).

Of the 61 dairies selling fluid milk, 45 retailed raw milk (4 of those also sold pasteurized milk) and 16 marketed pasteurized milk. The dairies selling pasteurized milk were generally located in those states where the sale of pasteurized milk is mandatory. The raw milk dairies were concentrated in California and the Northeast.

Of 50 states, 31 have mandatory milk pasteurization requirements; however, in 10 of these states, raw milk may be sold at the farm. Eighteen states license the sale of bottled raw milk. Of the 21 states where only pasteurized milk may be sold, only 4 have goat dairies. This means that over 70% of urban areas in the United States have no fluid goats' milk available (personal communication from Judy Kapture).

The industry has a real problem with bootleg sales of goats' milk from uninspected sources. Because the market potential is so small in many urban areas, the cost of installing pasteurizing and other processing equipment to meet state regulations is beyond the reach of most breeders that milk only a few goats. Energy costs are also too high to ship milk into a city from a distant source. Therefore, the would-be goat dairyman who has studied the competition for the market in terms of those who can legally sell goats' milk in a particular area, would still be forced out of business because of illegal milk sales by breeders who did not spend the money required for licensing, testing, inspection, and proper equipment.

Conclusions drawn during a three-year market development and merchandising research project by the Southern Agriculture Corporation indicated that raw milk production represented the greatest constraint in the development of an economically viable commercial, large scale, vertically-integrated dairy goat operation (12). Year round milk production must be achieved from a herd size approaching a minimum of 500 does. The product line should be narrow and limited at first. The preferred distribution route initially should be through a contract with a regional distributor/jobber. This would provide the most economical means of entry into a new geographical area. Once the market niche is established and year round supplies are available, only then should the merchandising effort be expanded.

CONCLUSIONS

Since the turn of the century, efforts to improve the dairy goat industry have been relatively disorganized. There has been little effort to develop, promote, or market dairy goats and their products nationally. If the dairy goat industry is to grow in the United States, there must be more well-planned coordinated marketing programs in addition to current research and development programs. The availability of quality products to the consumer will increase the cash flow to the producer, thereby completing the marketing circle and establishing the dairy goat as a viable entity in the economy.

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SIRE EVALUATION OF DAIRY GOATS

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ABSTRACT

Genetic ability of dairy goat bucks can be evaluated by comparing the performance of daughters milking under similar environmental conditions. The measure of daughter performance is 305-day lactation production adjusted to a standard age and season of kidding. Incomplete records are extended to a 305-day equivalent. Lactation production is computed from 1-day measurements approximately every month. The shape of the lactation curve is taken into account when computing lactation production. A buck can be ranked relative to another buck only if he can be compared either directly through daughters producing in the same herd as daughters of the other buck or indirectly by a chain of comparisons through other bucks connecting them. Only a small percentage of all bucks can be evaluated accurately because of the predominantly small-farm nature of goat husbandry and infrequent use of artificial insemination. Regional cooperative efforts to promote widespread use of those young bucks with potential genetic superiority should be encouraged so that accurate evaluations are possible. The potential for accurate evaluations can be increased by trading young does among herds and keeping a few daughters of several widely used bucks as a basis for comparison.

Keywords: Adjustment of records, artificial insemination, dairy goats, genetic evaluation, goats, reference sires, sire evaluation, small farms.

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INTRODUCTION

The genetic potential of dairy goats to produce milk and milk fat can be improved each generation if does and bucks with the best genotypes in the current generation are selected as parents of the next generation. The practical difficulty in mating "the best to the best" is determining or evaluating which does and bucks are the best. Bucks can be selected more intensely than does because one buck can sire many offspring each year. Consequently, bucks can make the greatest contribution to genetic improvement. Bucks must be evaluated through the performance of their daughters because only the performance of females can be measured. Therefore, evaluation of daughter performance is the first step in evaluating bucks.

EVALUATION OF DOES

A doe's production is the expression of both genetic and environmental factors. Some environmental effects can be removed from production records, thereby improving the utility of records as measures of genetic ability.

The measure of daughter performance is 305-day lactation production adjusted to a standard stage of maturity and season of kidding (4, 5, 8). Incomplete records are extended to a 305-day equivalent (10). Lactation production is computed from measurements of 1 day's production approximately every month. The shape of the lactation curve is taken into account when computing lactation production (6, 9).

The profitability of dairy goats is affected by factors other than milk production per lactation. Reproductive efficiency and number of offspring are clearly important. Research presently is being conducted to investigate reproductive traits in dairy goats (2).

Many environmental factors are common to does kidding in the same herd and year (herd-year). Within herd-year, comparisons among does are not affected by such factors. However, comparison of does in different herd-years should account for the different environmental effects. One technique is to compute the difference between a doe's production and the production of other does in the same herd-year; i.e., herdmate deviations. Differences in the genetic levels of herds are not measured by herdmate deviations; therefore, comparisons among does across herds would be biased by such differences. Little evidence exists of genetic progress for milk production; therefore, genetic differences among herds probably are not large. If genetic differences among herds did prove to be important, they could be accounted for by considering the genetic values of herdmate sires. Another technique is to estimate the environmental and genetic effects simultaneously. Best linear unbiased prediction (BLUP) methods involve this technique.

GENETIC EVALUATION OF BUCKS

Evaluation of bucks is more complicated than evaluation of does because a buck's performance cannot be measured directly. Information on a buck comes from observations on female relatives, particularly daughters. One buck's genetic ability to sire superior daughters can be compared with another's if they both have daughters kidding in the same herd-year. Indirect comparisons are also possible. For example, if two bucks have daughters in different herd-years but in common with daughters of a third buck, the two bucks can be compared through the third buck. Thus, daughters of bucks used in more than one herd-year serve to tie evaluations together. A buck cannot be evaluated if he does not have daughters in a common environment with daughters of any other buck, i.e., if he is the only buck with daughters in a herd-year and has daughters only in that herd-year. Even if a buck can be compared with some other bucks, it may not be possible to compare him with all other bucks because disconnected sets of records may exist; i.e., a group of bucks can be evaluated relative to others within the group, but no comparisons exist to tie this group to another group of bucks. This situation is quite likely because few bucks receive widespread use.

For dairy cattle, the widespread use of artificial insemination (AI) has made the accurate evaluation of many bulls possible. Although AI in dairy goats is not widespread, much interest has been shown in its development. Furthermore, AI may be the most practical way to use several bucks in a herd each year and to have daughters of many bucks in more than 1 herd-year.

An evaluation of a buck is composed of two parts: (a) An estimate of the amount by which production of a buck's daughters is expected to differ from production of a base group of does and (b) a measure of the reliability of that estimate. More information makes the estimate more reliable. Each daughter record provides some additional information; however, the distribution of daughter records among herd-years and the number of comparisons with daughters of other bucks determine the amount of additional information each record provides.

The prediction of future daughter performance varies with the amount of information available on current daughter performance. When many daughter records are available, future daughters are expected to perform similarly to the average of current daughters. When only a few daughter records are available, current daughter performance is regressed toward the average performance of the population or group that is expected to have similar genetic values. This regression means that future daughters are expected to perform between the average performance for the group and the performance of existing daughters.

RECORDS AVAILABLE FOR GENETIC EVALUATION

A review of national data (3) shows that the number of lactation records available for genetic evaluations increased from 2,858 for 1974 kiddings to 7,516 for 1977 kiddings and the number of herds increased from 389 to 1,171. The number of lactations per herd-year, however, decreased from 7.3 to 6.4. This drop was probably a result of an increase in the number of smaller herds on test in recent years. Of the 4,853 herd-years in the data, 942 (19.4 percent) had only one buck represented per herd-year. About 53 percent of the herd-years had fewer than four bucks represented.

Of the 10,102 bucks, 5,608 (55.5 percent) had only one daughter record. About 87 percent had fewer than four daughter records. A total of 9,812 bucks had daughters in herd-years with daughters of other bucks and thus could be compared to at least one other buck. Among these bucks, 5,068 (51.7 percent) had daughters in only 1 herd-year. Probably many sets of bucks are disconnected; i.e., they can be compared to other bucks in the same set but cannot be compared to bucks in other sets.

CURRENT EVALUATIONS

Genetic evaluations of bucks with daughters in California have been computed (1, 7) by researchers at the University of California at Davis. These evaluations are the first use of Dairy Herd Improvement records in the evaluation of goats in the United States. The records were provided by the Animal Improvement Programs Laboratory, which periodically receives records on goats along with records on cows from the regional dairy records processing centers. Records were selected to insure that only bucks that could be compared either directly or indirectly were evaluated. The California goat population was particularly suitable for these first evaluations because the relatively large herd sizes there allow for many bucks to have daughters in the same herd and year. The evaluations were based on completed records with at least 120 days in milk. Production for only the first 305 days was considered. Only bucks with five or more daughters were evaluated. Evaluations were computed from 9,807 daughter records in 493 herds for 1,861 bucks of the Alpine, Nubian, Saanen, and Toggenburg breeds.

IMPROVED GENETIC EVALUATIONS

A method of genetic evaluation can only extract information that exists in the data. To have accurate rankings of bucks and does, a system for widespread use of bucks must be implemented. Techniques that can be used to improve ties among bucks include use of reference bucks, increased distribution of daughters, and breed specialization.

Reference Bucks

If a few bucks are used widely, perhaps through AI, and therefore have daughters in many herds, other bucks used in those herds then can be compared through these so-called reference sires.

Increased Distribution of Daughters

The mechanics of AI may be a formidable obstacle, and therefore it may be more practical (although theoretically somewhat less desirable) to trade or sell doe kids so that offspring of a given buck are spread among many herds. A plan for regional cooperation might include recognition of promising young bucks, distribution of daughters, computation of local evaluations, and heavy use of bucks identified as best. If such a plan were successful, the best bucks would be in demand in other areas and would have daughters both inside and outside the region. Records from these daughters would provide a basis for national evaluations.

Breed Specialization

The presence of several breeds in the same herd complicates evaluations because difference in standardized production between two does of different breeds in the same herd would be due partly to breed as well as to sire differences. The most rapid progress can be made by breed specialization so that breed differences do not contribute to differences among herdmates.

SUMMARY

Genetic evaluation is an evolving process. Preliminary identification of superior bucks should encourage their widespread use. As a consequence of such widespread use of some bucks, all bucks could be evaluated more accurately, thus promoting genetic progress.

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PART-TIME AND SMALL-SCALE SYSTEMS FOR SWINE PRODUCTION

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ABSTRACT

Several swine production systems which are or could be used by part-time or small-scale farmers are identified and discussed. Since much of the Northeast Region is best adapted for forage production and has climatic conditions making non-confinement systems difficult to operate in the winter, small-scale swine production is not expected to grow significantly in popularity. However, some types of feeder pig production systems should remain viable in the more southerly portions of the Region.

Keywords: Part-time farms, small-scale farms, swine, production systems, farrowing facilities, feeder pigs, livestock markets, environment.

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In my experience, part-time and small-scale swine enterprises generally are low-investment, low-intensity enterprises where the operator is either unable or unwilling to invest large sums of money into the operation. Successful small operators sometimes expand their enterprises into large-scale, full-time operations.

According to a survey by Kerr (2) of small farms in the Northeastern Region, small-scale swine production is not a predominant enterprise. Of the 70 counties surveyed, only four had swine ranked in the top three most important agricultural commodities produced on small farms. The paucity of small-scale swine operations in the Northeastern Region may be related to geography and climate, since most of the states are located in climatic zones where year-round swine production is very difficult without using expensive controlled environment confinement facilities and where crop production is geared toward forages rather than grains. Other factors, such as the lack of readily available slaughter facilities or livestock markets for swine, may also limit the popularity of swine as a small-scale enterprise.

Farmers who wish to become swine producers may choose from one of several types of pork production systems. The farrow-to-finish system encompasses the whole life cycle of the pig, where a producer maintains a breeding herd to produce baby pigs and then raises the offspring to a market weight of about 100 kg. The production cycle can, however, be broken into two parts, feeder pig production and feeder pig finishing, and a farmer can choose to do one or the other, depending on his individual situation.

Feeder pig finishing, which involves buying 18 to 27 kg pigs and feeding them to market weight, is the least complex swine production system. However, finishing pigs consume large amounts of feed, which the operator either has to grow or purchase. The small farmer is at a great economic disadvantage in this system because he is not large enough to justify feed processing equipment for his home-grown grains or to benefit from bulk prices available to large farmers who purchase enormous quantities of ingredients or mixed feeds. Since feed usually represents about two thirds of the cost of finishing feeder pigs, I suspect that simple economics is the reason we have so few small-scale feeder pig finishing enterprises.

Feeder pig production, when compared to feeder pig finishing, requires more labor and less feed per dollar's worth of product produced. As with the production of other agricultural commodities, there must be a competitive market for the feeder pigs produced. Many of these feeder pigs must eventually be bought and fed out by large-scale feeder pig finishers, and buying and handling small groups of feeder pigs from individual small producers is cumbersome at best. Lack of access to several potential buyers also may force small feeder pig producers to accept low prices for their pigs because alternative buyers are not available.

Several Northeastern Region states, such as Maryland and Delaware, have solved this problem by holding regular, producer-run feeder pig sales. Pigs sold through these sales are inspected, weighed and graded and then sold by auction. Such a system benefits both buyers and sellers. Buyers save time and money by being able to purchase large numbers of uniform pigs at a single location. Sellers, even those bringing small numbers of pigs, are able to offer their pigs to more than one buyer and thereby receive a competitive price for them. An interesting side benefit of the feeder pig sales has been the educational value to producers of seeing each others' pigs sold. Producers offering high quality, healthy and well-conditioned pigs consistently command higher prices from the buyers. A number of producers now pay closer attention to boar selection and some have changed management procedures in order to upgrade the quality of their feeder pigs.

Facilities used by small-scale swine producers may range from total continement to pasture rearing, but most small total confinement operations that I've seen were the result of renovating an existing barn rather than building a new facility. Minimum facility requirements for finishing feeder pigs include at least a shade in the summer and protection from the elements in the winter. This is usually accomplished most economically by housing them in an open-front building on an exposed concrete slab. Since supplemental heat is not usually provided, the efficiency of growth in these facilities during the winter months is greatly dependent on the severity of the climate.

A number of producers have taken advantage of the moderating effect of underground soil temperatures by renovating old bank barns for use as swine facilities. Such structures work well as farrowing facilities, especially since they remain comfortably cool in the summer without requiring a lot of ventilation.

The producer who lacks an existing building but who wishes to farrow all year can make use of individual, portable farrowing houses. These units can stand alone or be attached to a concrete slab. Supplemental heat, such as a heat lamp or floor pad, must be supplied for the baby pigs in the colder months but otherwise the units are very inexpensive to operate. This system requires more labor than does a total confinement building but the facility investment cost is approximately halved with the outdoor system.

Isler and co-workers (1) at the Ohio State University reported on research with a low-investment, one-litter feeder pig enterprise that is ideally suited to the part-time swine operator. The system is designed for outside farrowing in the late spring and early summer on rough land that has little or no alternative agricultural use. Bred gilts are placed in the farrowing area to build their own nest prior to farrowing. The gilts are sold after weaning their first litters and the offspring are sold as feeder pigs, except for the young gilts kept to produce the next year's litters. These gilts were wintered in an old barn with a concrete apron. Table 1 is a summary of the success of this system, used in southeast Ohio,

Table 1.--Returns Over Feed Costs[1]

Year	1974	1975	1976	1977	1978	1979
No. of Litters	18	24	24	25	22	24
Avg. Litter Size Marketed	4.10	5.88	7.00	6.08	8.00	5.79
Returns ($):						
Sows	2375	6208	2636	3912	4575	3618
Pigs	1901	6403	4868	5346	8860	3915
Gilts Retained				1262	1821	1070
Total	4276	12611	7504	10519	15256	8543
Expenses ($):						
Gilt Value	2520	1050	1930	797	1262	1821
Feed	1341	2656	3245	3896	3822	4869
Other	107	0	0	200	300	300
Total	3968	3706	5175	4893	5384	6990
Returns Over Feed Costs ($):	308	8905	2329	5626	9872	1554

[1] Isler *et al*., 1980

over a six-year period.

The returns from such a system are highly variable, depending greatly on the weather at farrowing and feeder pig prices. However, it does afford a small farmer the opportunity to enter the swine business with a minimum of investment capital while making use of untillable land. The other advantage I see is that it makes swine production a "seasonal" enterprise, concentrating the bulk of the labor into the summer months. In addition to being a pleasant time to work outside, the timing allows for the assistance of the operators' children, who will be on vacation from school shortly after farrowing begins.

The technology for small-scale swine production is well documented, and for the most part, widely available. Building plans and publications on management procedures, feeding, etc., are available through county extension offices. The Pork Industry Handbook, also available through the Cooperative Extension Service in most states, addresses specific topics related to swine production and management. Sections 13 through 17 of the Handbook outline five different pork production systems and present a business analysis of each; several of these systems are suitable for part-time producers. The University of Missouri--Columbia Extension Division has also published the design of an outdoor farrowing and nursery unit system using individual farrowing houses, a system that is ideal for a part-time producer who may later want to expand.

Ultimately the success or failure of the part-time swine enterprise depends on the operator's ability to chose an economically viable system and to optimally utilize the resources available to him. As energy prices continue to rise, the economics of systems with minimal energy input will improve. Public sentiment against "mass-production" of livestock on large farms may even create a specialty market for pork raised under non-intensive conditions, much as the demand for "organic" food built a market for farmers who minimize the use of agricultural chemicals in fruit and vegetable production. Other speciality items, such as small pigs for barbecues, are also easily handled by the small producer.

Although the fact that the pig cannot utilize forage like grazing ruminants will limit the economic potential and the popularity of small-scale swine production in the Northeastern Region, certain production systems in some areas of the Region will continue to provide income to a number of small, part-time farmers. The technology for small-scale swine production is well-documented and available to producers who request it. Many of the Cooperative Extension Service County Agents have the knowledge to assist farmers who have or wish to start small-scale swine operations. However, in my experience, these producers require one-on-one assistance and agents often may not have enough time to satisfy the needs of large numbers of small-scale operators.

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CONSERVING OPTIONS:

AN OVERVIEW OF SMALL FARMS CONCERNS

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ABSTRACT

The importance of conserving or increasing options is a policy goal too often ignored by researchers, decisionmakers, and advocates. Options provide the flexibility any important sector needs to adjust to changing conditions. A viable and prosperous subsector of small farms (small to moderate scale family farms) provides a range of options essential to meeting the changing and uncertain conditions facing American agriculture. Therefore, because small farms are essential to maintaining options and flexibility in agriculture; and because controllable factors influence the economic well-being of all family farms; and because a number of desired societal goals would be enhanced by a flourishing small farms subsector, small farm concerns warrant the attention of public policymakers and researchers. Current small farms research suffers from simplistic definitions, chronic gaps in information, obsolescence, fragmentation, and lack of predictive validation. An agenda for small farms research should examine issues such as production efficiency and technology; marketing; government price and income policies; credit; taxes; energy; off-farm income; and the role of small to moderate scale family farms in achieving an optimum structure of agriculture.

Keywords: Credit, efficiency, energy, extension, family farm, marketing, mechanization, off-farm income, options, policy, research, rewards system, small farm, structure, taxation.

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INTRODUCTION

The information in this paper is presented in four sections: The Importance of Options; The Case for Concern; The Case for Research; and An Agenda for Small Farms Research. The approach to designing a small farms research agenda and the suggested research questions were developed as part of the National Rural Center's Small Farms Policy and Research Agenda Project. The paper seeks to present an overview of small farms concerns but not a detailed justification of those concerns.

THE IMPORTANCE OF OPTIONS

The importance of conserving or increasing options is a policy goal too often ignored by researchers, decisionmakers, and advocates. Yet the availability of options is necessary to:

> Allow a marketplace economy to operate;
>
> Ensure flexibility required to cope with changing conditions;
>
> Maintain diversity demanded of a society in a large country with different ethnic, geographic, and political structures; and
>
> Provide opportunities and choices a free and upward mobile society needs to work.

More specifically, to remain vigorous, a marketplace economy needs competition, innovation, and new entrants. A single strategy can be overtaken by events and people's inability to predict the future, thus increasing society's vulnerability to changing conditions beyond its control. A centrally dominated economy, economic sector, or large economic enterprise, whether privately or publicly controlled, can find it difficult to respond to the diversity of a large country and to changing conditions. Though the definition of "upward mobility" may be changing, it remains true that a free people require a full range of economic opportunities.

We consider it self evident therefore that conserving options is an important policy goal in any sector as critical to the well-being of society as is agriculture. Furthermore, options should be eliminated only with great care, by choice and not by inadvertance or by default. The case for maintaining options cuts across liberal and conservative lines with both camps often holding contradictory positions on the question. The case for concern about small farms rests on the importance of conserving options as discussed below.

THE CASE FOR CONCERN

In a time of increased competition for public resources, diminished confidence in government, and growing support for marketplace solutions, the case for concern about small farms rests upon the premise that a mix of farm sizes and ownership patterns is in the national interest. Small farms are obviously necessary to achieve a desirable mix. The disappearing middle syndrome, namely, the trend toward large and very small farms, with fewer and mid-size family farms, is not the inevitable result of natural or market forces.

Policy variables can be adjusted to enhance the position of small farm operations. In our opinion, societal and economic benefits will, in many instances, justify the costs of such policy adjustments.

Current trends seem clearly to support the contention that the fate of small farms warrants the concern of the research and public policy communities. This paper identifies a series of policy variables affecting the economic potential of small farms which ought to be investigated. In many cases, perhaps in most, the state of the art does not clearly illuminate key policy questions. It is the authors' thesis that when we don't know enough, the research community should pursue the information, and the policymaker should conserve the options until such information becomes available.

Before proceeding, we will offer several disclaimers and definitions.

As suggested by the title, this paper is a broad overview of small-farm concerns. As such, it seeks to raise more questions than it answers. The authors not only recognize the diversity found in rural areas, and the diverse goals, sizes, resources and modes of operations which can be lumped under a heading of "small farms," but we also believe strongly that any sector of the economy must be diverse if it is to be flexible and resilient in changing and uncertain conditions. Just as small businesses are important generators of innovation, jobs, income, and flexibility, so can small farms help bring these benefits of diversity to agriculture. It follows then that we choose to define a small farm in terms of success and are concerned with those policy variables that are barriers to enhancing the economic viability of small farm operations and families. We therefore agree that small farm policy should be focused by the following definition of a small farm family:

> the family or individual must rely on farm income for a substantial share of livelihood;
>
> the operating family or individual must manage or control the farm business and must perform most of the farm labor (except in peak seasons); and
>
> family or individual income does not exceed the median nonmetropolitan family income in the state where the farm is located.

Obviously, this definition excludes many operations which might otherwise be considered small and includes others that are considered moderate size family farms. However, just as obviously, policies designed to enhance the economic viability of farm families within the definition will also benefit many not included in the definition. Further, since conserving options and diversity is a principal goal, a distinction between small and moderate size family farm serves no real purpose. Therefore, we use the term "small farm" as a convenient notation meaning small-to-moderate scale family farm.

The Need For Diversity

The structure of American agriculture has undergone a massive transformation over the past forty years. Mechanization has displaced millions of farmers and farm workers, substituting capital for labor, while greatly increasing the labor efficiency of those who remain in farming. It has led to steady growth in the average size of farms, in the need for capital and credit, in the demand for ever more sophisticated managerial skills. Also, many functions (raising seeds, producing fertilizer, processing, transporting, marketing, etc.) have been shifted off the farm -- some moving to input suppliers and some to processors and distributors. As a result, most farmers have been left with the highly specialized task of producing raw agricultural products, thus linking them more closely and making them more dependent upon the nonfarm sector than in the past.

The results of this transformation are remarkable. The American farmer and a host of supporting actors have compiled a record of food and fiber production second to none. But the trend toward larger, specialized, industrialized farming is not without costs and not without implications for the long-term productivity and profitability of farming.

It has long been recognized that mechanization of farming has helped fuel a decades-long rural-to-urban migration which has left many rural communities depressed and many urban areas crowded with people untrained for urban jobs and urban life. Only recently, however, have questions been raised about the impacts of and potential vulnerabilities created by an increasingly concentrated industrialized and specialized agricultural sector.

Increasing concentration has resulted in oligopolistic market conditions for many commodities and agricultural inputs, creating conditions under which both consumers and producers are captives to high prices which result from limited economic competition.

As a result of trends toward regional specialization in crops and livestock production, crop vulnerability to insect and pest attack has increased. For example, sixty-nine percent of the nation's corn and sixty-five percent of the wheat are grown in eight north central states. And though there are ninety-seven hybrid corn varieties available, six of these accounted for seventy-one percent of the corn acreage in 1972, and in fact, these six varieties are all related. The use of a single cytoplasm to produce nearly all the hybrid corn grown in the U.S. made it possible for a single parasite mode to reduce the 1970 corn crop by fifteen percent.

In addition, regional specialization creates critical dependency on transportation, storage, and processing facilities to deliver food and fiber thousands of miles from producer to consumer. In Massachusetts, for example, over eighty-five percent of the food consumed in the state is imported; the city of Boston generally has only a one-week reserve of food, making millions of people vulnerable to disruptions in energy supply or transportation lines.

Climate changes are also of concern. Recent scientific examination of past temperature patterns concludes that agriculture as we know it evolves during an abnormally warm period. In the shorter term, the Hale double-sunspot cycle of twenty-two years exerts important but not fully understood influence on precipitation patterns nationwide and could significantly affect agricultural production. Atmospheric particles, reduced ozone, and increased carbon dioxide in the atmosphere, acid rain, and unintended effects of weather modification programs may also have significant but not reliably predictable impact on agricultural production.

The depletion or contamination of various aquifers and rivers and increased competition for water threaten many of the nation's most productive farm areas. And finally, it is estimated that the nation loses 1.926 million tons of topsoil annually from cropland through erosion.

Other changing conditions with unknown consequences for farming include escalating land prices, high interest rates, growing debt burdens, continued inflation. And finally, as the farm population dwindles, and with it the number of communities and people directly dependent on a viable farm economy, so too does political support for prudent farm policies dwindle.

Obviously, flourishing small farms alone will not solve these problems, but diversity in farm sizes, methods, and ownership patterns can help. Just as clearly, one cannot have a mix of farm sizes without some small operations, and one cannot ensure a mix of farm sizes without a steady stream of new entrants. It is hard to imagine such a stream if the entry point is large, capital-intensive farms.

Policy Variables and Societal Goals

Neither the farm sector nor any other sector, for that matter, currently operates in a free market economy. Farm decisions and profitability are affected by tax policies, credit policies, interest rates, research policies, educational and information transfer policies, fiscal and monetary policies, and government price supports and income transfers. Few if any students of those factors will argue that these policies are the inevitable result of a free marketplace, though many policies have been adopted to react to some perceived economic problem or trend. There are policy variables that can and have been adjusted. Of course, such nonpolicy factors as weather, soil conditions, personal abilities and resources also affect the well-being of farm operations and can overwhelm the impacts of policies. However, it is also true that these "controllable" policy variables affect the profitability and ultimately the survival of all sizes of farms, small and large.

Certainly the costs and trade-offs involved in adjusting policies need to be understood and measured against benefits and desired goals. The principal goal of agriculture policies must be a profitable, sustainable farm sector that produces the food and fiber commodities required for domestic and international markets at affordable prices. Concern for the small farm becomes part of that goal because conserving options is crucial to ensuring sustainability over time. At the same time, a flourishing small farm subsector can enhance such other desirable goals as reducing poverty; encouraging rural development and balanced national growth; offering opportunities; and increasing independence of individuals, communities, and regions.

In summary, conserving the small farms option warrants public attention on the grounds: (1) that diversity of farm size and ownership pattern is needed to ensure a sustainable agriculture sector in a time of changing conditions and unknown impacts; (2) policy variables as well as other causal factors apparently affect the economic viability of small farms; and (3) a number of desired societal goals would be enhanced by a flourishing small farms subsector.

THE CASE FOR RESEARCH

Even if a subject warrants public concern, a case must still be made that a useful research program can be developed. The examination of the case begins with a review of the current state of knowledge about small farm issues. While present conditions are well-documented in some areas, the existing knowledge generally does not provide adequate explanations of existing trends or the causes, nor has research provided solid bases for predicting the outcome of alternative policy initiatives under the variety of conditions and resource combinations found on small farms. Several general types of deficiencies can be found in the existing literature.

Simplistic definitions: Most studies fail to differentiate among various types of small farms. Failure to recognize variations in family aspirations and resources and other farm attributes has contributed to a single-dimension view of small farms.

Chronic gaps: Information has never been collected and synthesized on such topics as goals and motivations of small-farm families; energy use; consumption and investment behavior; differences in patterns of resource use among farms of various sizes; and more.

Obsolescence: Most of the research literature is out of date or not valid for current technology, prices, or government programs.

Lack of predictive validation. Conventional macro-economic theory largely ignores or assumes away the complexity and variability found on farms and has not been reliable for predicting the success or failure of small farms or programs intended to help them.

Fragmentation: The entire body of small-farms research lacks a comprehensive framework. Typical agendas for small-farms research are strings of seemingly unrelated items, with no underlying rationale and no apparent plan or cohesive framework.

Three possible causes for these deficiencies are: limited rapport between conventional scientific research and the "alternative" literature; inadequate funding, and contra-productive administrative structures.

While some "alternative" literature on small farm trends and experiences can be faulted for failing to meet standards of repeatability, objectivity, rigor and validity, it also is not encumbered by many of the preconceptions and boundaries that can inhibit the imaginations and restrict the scope of more orthodox research. Too often the reaction of the more traditional research community is to reject or ignore creative ideas presented in alternative literature because they lack scientific rigor. A more useful response would be to apply scientific rigor to the more promising innovative ideas.

Administrative structures that tend to inhibit the amount and effectiveness of small-farms research include: lack of farmer input into research, administrative and statutory separation of research and extension, emphasis on individual single-discipline research projects in both funding and reporting procedures, and the academic and bureaucratic reward system. Studies are needed to determine ways to improve the administrative structure within government and academic research institutions.

Not surprisingly, with the cost of good research climbing and budgets decreasing, small farms research projects face increased competition for available resources. Equally troublesome, small farms research starts from a very small base. One cause for the low level funding is the low priority given small farms concerns and potentials. Another is the tendency to present lists of research projects rather than a research agenda with definable social and economic goals which relate to needs of users, from the farmer to the policymaker.

One practical way to develop a comprehensive and integrated program of small-farms research is through the use of a farming systems research and development approach, as illustrated by the programs of international institutes in Mexico, India, Nigeria, and other developing nations. See, for example, (1). A farming systems approach views the farm or production unit and the rural household or consumption unit in a comprehensive manner and recognizes the interdependencies and interrelationships between the natural and human environments. It explicitly recognizes farmer goals and seeks to include community and societal goals. The use of multidisciplinary teams of researchers faciliates the interaction of technical and socio-economic perspectives and complements, rather than overriding the wisdom and experience of farmers and extension workers. A farming systems program is an integrated combination or sequence of scientific studies and practical problem-solving research projects that cuts across disciplinary and sometimes even geopolitical boundaries to wed biological, physical, and social sciences into a meaningful body of knowledge relevant to intended users on a continuing basis.

Within this framework, a research agenda can be constructed to examine small farms within the broad societal goal of maintaining an agricultural sector efficient and productive over time in face of changing conditions and uncertainty. Specific sub-goals could include:

1. Maintaining and increasing the diversity of agriculture by improving the economic viability of small farm operations and easing entry of qualified individuals into farming.

2. Enhancing independence of rural individuals, rural communities, and regions through increased agricultural production from local small farm operations.

3. Enhancing the goal of balanced national growth through increasing the capacity of rural communities to provide a decent quality of life.

And, of course, each of these sub-goals includes a range of desirable outcomes, from decreasing dependencies on fossil fuels and petroleum products to encouraging efficient, reliable marketing systems responsive to a diverse agricultural sector.

To help conceptualize how to develop a research agenda (as opposed to list of research projects) Figure 1 shows relationships among factors affecting the prosperity of small farm families. The arrows indicate direction of influence. Drawing on the factors identified in those figures, the following section suggests a small farm research agenda.

AN ABRIDGED AGENDA FOR SMALL FARMS RESEARCH

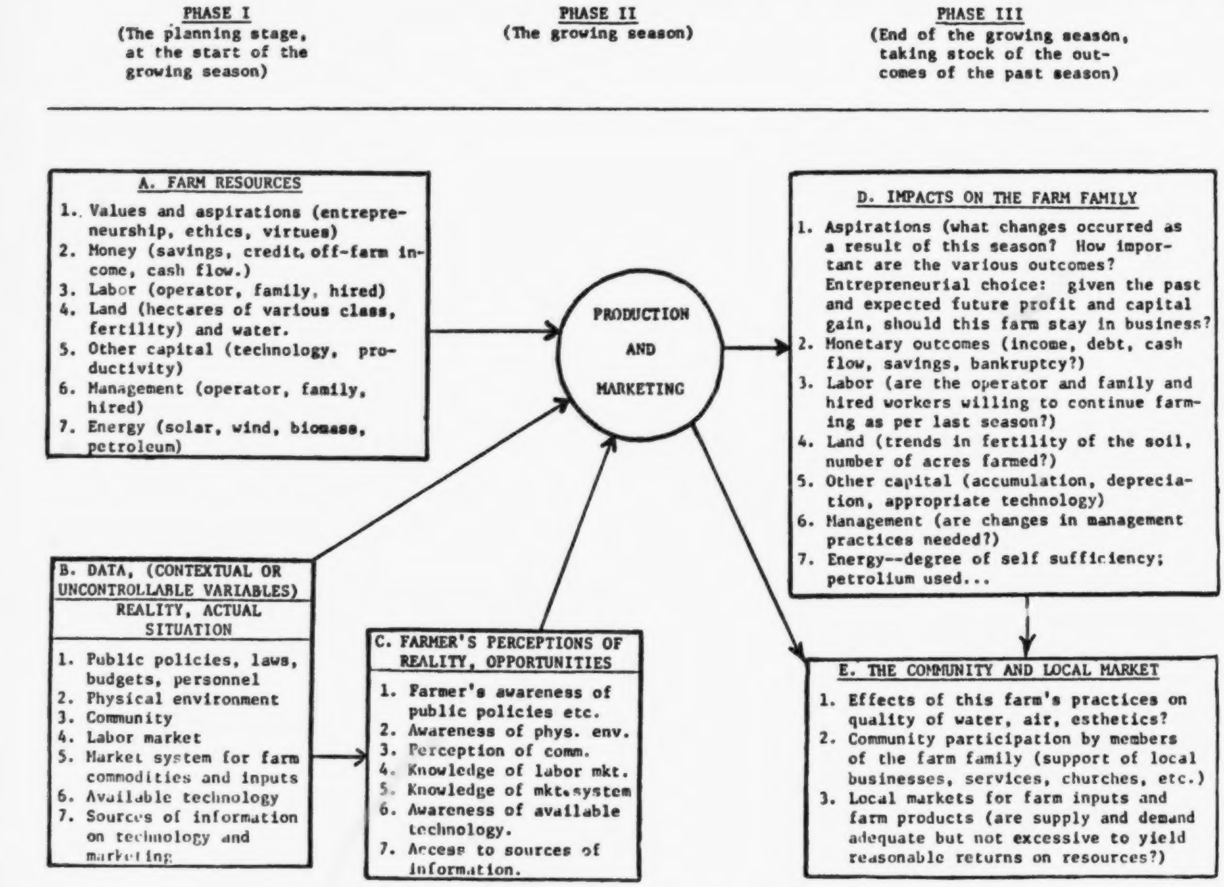
The following recommendations call for research related to the survival and prosperity of small to moderate scale family farms, or briefly, small farms. The recommendations fall into eight general categories: efficiency and technology, marketing, government price and income policy, credit, taxes, energy, off-farm income, and the structure of agriculture. Space does not permit specific justifications for each suggestion. Rather, they are offered as an illustration of small farms concerns that warrant the attention of researchers and policymakers. A more comprehensive discussion of the research agenda is presented in An Agenda for Small Farm Research. (2)

Production, Efficiency and Technology

Research is needed to develop and evaluate practical and profitable technology appropriate to the resources and needs of small-farm families, including machinery, buildings, fences, and storage facilities. Research and education are needed to integrate the physical, biological, and marketing knowledge into a comprehensive model that includes the family's goals and values and the trade-offs between farm and off-farm use of the family's resources.

> How can optimizing models, such as linear and quadratic risk programming, be used, possibly in conjunction with simulation models, to devise management strategies that will enhance the survival potential of small-scale farmers?
>
> What are the managerial, labor, capital, and other requirements for various enterprises (crop and livestock) relevant to small-scale farms in various locations?
>
> What are the realistic prospects for making organic farming, integrated pest management, and various low-cost, low-energy production methods more practical and profitable for small-scale farms?
>
> What are the circumstances and factors that determine the effectiveness of information delivery systems to small-scale farmers? What are the barriers to use of existing technical information from past and present agricultural research (on production and marketing) by small-farm operators?

Given the gaps between the technology available and the technology needs of small farms, research is needed to develop technology appropri-



PHASE I
(The planning stage, at the start of the growing season)

PHASE II
(The growing season)

PHASE III
(End of the growing season, taking stock of the outcomes of the past season)

A. FARM RESOURCES

1. Values and aspirations (entrepreneurship, ethics, virtues)
2. Money (savings, credit, off-farm income, cash flow.)
3. Labor (operator, family, hired)
4. Land (hectares of various class, fertility) and water.
5. Other capital (technology, productivity)
6. Management (operator, family, hired)
7. Energy (solar, wind, biomass, petroleum)

PRODUCTION AND MARKETING

B. DATA, (CONTEXTUAL OR UNCONTROLLABLE VARIABLES) REALITY, ACTUAL SITUATION

1. Public policies, laws, budgets, personnel
2. Physical environment
3. Community
4. Labor market
5. Market system for farm commodities and inputs
6. Available technology
7. Sources of information on technology and marketing

C. FARMER'S PERCEPTIONS OF REALITY, OPPORTUNITIES

1. Farmer's awareness of public policies etc.
2. Awareness of phys. env.
3. Perception of comm.
4. Knowledge of labor mkt.
5. Knowledge of mkt. system
6. Awareness of available technology.
7. Access to sources of information.

D. IMPACTS ON THE FARM FAMILY

1. Aspirations (what changes occurred as a result of this season? How important are the various outcomes? Entrepreneurial choice: given the past and expected future profit and capital gain, should this farm stay in business?
2. Monetary outcomes (income, debt, cash flow, savings, bankruptcy?)
3. Labor (are the operator and family and hired workers willing to continue farming as per last season?)
4. Land (trends in fertility of the soil, number of acres farmed?)
5. Other capital (accumulation, depreciation, appropriate technology)
6. Management (are changes in management practices needed?)
7. Energy--degree of self sufficiency; petrolium used...

E. THE COMMUNITY AND LOCAL MARKET

1. Effects of this farm's practices on quality of water, air, esthetics?
2. Community participation by members of the farm family (support of local businesses, services, churches, etc.)
3. Local markets for farm inputs and farm products (are supply and demand adequate but not excessive to yield reasonable returns on resources?)

Figure 1. Factors Affecting the Survival and Prosperity of Small-Scale Farm Families

ate to small farms -- such as tractors, implements, tillage and harvesting equipment, buildings, fences, and storage facilities. Further research is needed to determine the impacts of mechanization on the survival of small farms and the quality of life among farm families, hired laborers, and rural communities. Research is also needed to determine ways to ameliorate or prevent the detrimental impacts (accidents, displacement of workers) of mechanization. Research should include greater emphasis on flexible enterprise combinations, use of appropriate technology, and realistic combinations of farm and off-farm income activities for small farm families having various resource endowments and sizes of farms.

Marketing

To what extent do marketing orders and other government regulations present a problem to small-farm operators within the present system?

What kinds of marketing information are available to small-farm operators in different locations, and how can this information be made more congruent to their information needs?

What are the benefits and limitations of alternative marketing systems such as direct marketing and farmers' markets?

To what extent has the current marketing system made consumers in some parts of the country vulnerable to transportation stoppages and increased energy costs? To what extent does moving toward more localized food production and marketing systems, featuring prosperous and viable small farms, offer advantages to small-farm operators and consumers?

GOVERNMENT PRICE AND INCOME POLICY

In order for substantive research to yield insights into the effects of public price and income policies on small farms, additional data are needed to facilitate more detailed analyses according to types of small farms. Especially needed is longitudinal information about the dynamics of economic decisions at the farm level Research is needed to determine the differential effects of uniform incremental changes in product prices, incomes, and volumes of production (characteristic of most current public price and income policies) upon the viability of farms of varying sizes. Research is needed to clearly define the following alternative types of price and income policies and to reliably estimate the relative impacts on farms of different sizes and on other policy goals. Specifically:

Measurement of program participation rates by farms of various sizes and types is needed to provide a better understanding of the variables affecting participation rates and the effects of different participation rates among farms of varying sizes.

Research is needed to determine the relationships among the level and stability of income, mobility, and trends toward farm consolidation.

The relationship between risk reduction (through various policy provisions) and farm viability, by size of farm, should be investigated.

How would different types of insurance programs distribute the benefits and costs among farms of various sizes?

To what extent are the interests and well-being of small-farm families taken into account in the process of creating regulations and procedures used in implementing farm credit, price supports, and other policies?

Credit

What are the costs and benefits to borrowers and lenders of various types of loans and loan programs? Research is needed to project future credit needs of agriculture in general and to small farms specifically and the ability of lending institutions to meet those needs. In addition to research that focuses on flow of funds in agriculture, in general, there is a need for research that specifically examines the flow into the small-farm sector.

What are the sources of the flow? How important to the farm family's credit rating are off-farm earnings, and how are these, in turn, affected by the business cycle? How is the flow of funds into agriculture affected by changing monetary conditions? What new institutions, or changes in institutions, are needed to enhance the flow of funds to small farms, or retard its flow to larger farms? Can such a flow of funds be successfully targeted to small farms without large leakages or inadvertant damage to large farms?

What is the impact of credit regulatory practices on farms of different sizes? For example, how do policies regulating branch banking affect loan funds available to small farm operators?

Research is needed on risk-aversion strategies, including variable repayment schedules and the design and construction of suitable, simple, low-cost, on-farm storage units and cooperative storage arrangements that reduce the vulnerability of small farms to price fluctuations.

Research is needed to better understand the barriers to entry into various types of farming in various locations.

To what extent does subsidized credit make entry of new family farms more difficult by fueling further inflation of land values?

Taxes

What are the advantages and disadvantages of cash accounting versus accrual for various kinds of small farms (retirement, part-time crop farms, speciality-crop farms)? What types of tax advantages would be useful to the beginning farmer? How and to what degree do tax concessions drive up the price of land and what is the relationship between rising land prices and the economic viability of small farms?

How could the tax system be altered to encourage on-farm innovation and experimentation concerning alternative farming systems suitable to the needs of small farms? If changes in the investment tax credit were to eliminate subsidies for capital-intensive production, how would small farms be affected?

What are the implications of a graduated land tax (where the property tax rate increases with the size of the farm)?

What are the tax implications of land-use planning initiatives on the economic viability of small farms and tax bases of rural communities; and what are alternative methods of generating local revenue if property taxes are reduced?

To what extent does the existing tax code give tax advantages to large farms, and do these tax advantages, if any, give large farms a significant competitive advantage over small farms?

Energy

Critical reviews in existing studies of the impact of energy problems on farmers' incomes, production costs, resource use, and on food prices and availability are needed. While most available research has focused on the impacts of energy price increases, more research is needed on the effects of energy supply reductions. Specifically:

A method is required to calculate the "true" value of energy -- not just its monetary value. Such a method would take into consideration price regulation, environmental externalities, tax policies and subsidies, future needs, and the divergences between private and social energy costs. Most importantly, consideration must be given to the finite nature of fossil-fuel energy.

Greater attention should be given to small farms in research on low-energy grain drying; minimum tillage; animal power; improved irrigation efficiency; alcohol and methane use, in addition to other techniques possible for reducing energy use but still requiring further development to become useful in farm operations.

Further research concerning production methods utilizing reduction in the use of energy-intensive agricultural chemicals, such as pesticides and fertilizers, should be undertaken.

Research is needed on what systems of on-farm energy production (including fertilization and pest control), biomass, or wind and solar sources of energy are best suited to the various situations typical on small farms in different geographic location.

Off-Farm Income

What is the role of off-farm income in determining the economic and social well-being of small-farm families and the communities in which they are located?

What types of small-farm enterprises are compatible with existing off-farm employment opportunities; and, conversely, what off-farm employment opportunities are compatible with existing small-farm enterprises? Where incompatibilities exist, what are potential alternatives?

Structure of Agriculture

Research is needed to determine trends in the number and commercial importance of farm businesses not owned by the family living on the farm.

How is the structure of agriculture affected by the aspirations, goals, and expectations of small-farm families? Do goals of small-farm families differ from those of large-farm families? How important are noneconomic goals? How are goals of a small-farm family influenced by the family's off-farm employment, stage of the family life-cycle, ages and health of the operators and family members, and cultural norms of the community in which they are located?

What are some of the externalities that need to be considered when determining costs and benefits of differing structures of agriculture? Differences in management practices between large and small farms should be examined to determine if there is a consistent difference in quality of husbandry (care of the soil, the animals, and other farm resources) on farms of various sizes. What are the economic and environmental costs and benefits connected with differing farming methods, and are there economies or diseconomies of size in improved environmental practices?

How can the relationship of policy decisions to the structure of agriculture be integrated into a formal modeling effort to improve the explanatory and predictive capabilities of political and economic theory?

These and other research questions should be addressed in the interest of maintaining small to moderate scale family farms as a valuable option within the structure of American agriculture.

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FARM FAMILY MEMBERS: CONTRIBUTIONS, ASSETS, AND LIABILITIES

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ABSTRACT

Small farm family goals, decision-making, task involvement, off-farm employment, and the emotional support of family members are reviewed as to how these contribute to the small farm and the small farm family. A national survey of farm women, State, and regional research projects were reviewed in an attempt to classify the contributions as benefical or costly to the farm and family. The contributions of small farm families are beginning to be recognized in estate tax reforms.

With a decline in the farm population and an increase in farm size, the economic well-being of the small farm family needs to be studied in more depth than current data permit. Insufficient data at the local, state and National levels inhibit the appropriate analysis and use of research findings. Extension educational programs are assisting small farm families; however, more research is needed to further efforts to improve the quality of small farm living.

Keywords: Small farms, small farm families, economics, goals, decision-making, task involvement, off-farm employment, emotional health, research needs, and farm women.

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Small farms--other than size, what makes them unique? It is the family members contributions that make these farms a viable agricultural unit. The small farm cannot survive without the support of the family. Resources on the small farm are intertwined between the farm unit and the family unit and often become inseparable. If the family is an integral part of the small farm, what does it contribute and are these contributions of benefit to both the farm and family?

With a decline in the proportion of people living on farms and an increase in the average size of farms (25), concern has arisen for the economic well-being of the small farm family. Fears range from a disappearing lifestyle to control of food and fiber production by large conglomerate farm corporations. As fewer farm families remain in the occupation, the answer to questions like "Who will sit up with the corporate sow?" (6) becomes pertinent to the future structure of American agriculture.

The term family farm has recently become synonymous with small-sized farm operations, although some large farms are operated and owned by families. The concept of family farms was originally supported by Thomas Jefferson, but the term did not appear until 1913 when George Warren defined the family farm as a place on which the family provided most of the labor (2). In the 1940's, the U.S. Department of Agriculture defined the family farm as a farm on which the operator, devoting substantially full time to operations with the help of other family members and without the employment of more than a moderate amount of outside labor, can make a satisfactory living and maintain the farm operation. In the 1960's the Department's definition became simplified with the family farm as a place where the family performed most of the managerial activities and supplied most of the farm labor.

Desiring to place policy emphasis on the plight of the small (family) farm and to settle resulting disagreement as to what was a small farm in the late 1970's and early 1980's, the U.S. Department of Agriculture defined this farm using the following definition:[2]

- Family members provide most of the labor and management.
- Family net income from all sources (farm and non-farm) is below the median nonmetropolitan income of the state.
- The family is dependent on farming for a significant [portion], though not necessarily a majority, of its income. (1)[3]

The first and third aspects are difficult to use in identifying small farms in research due to problems in quantifying the terms "most" and "majority". Estimates of the number of small farms vary with the definition used. Usually the family net income is used to identify small farms. Using the median nonmetropolitan income of about $17,800 in 1980, approximately 52 percent of the total number of farms can be classified as small (1). These families control 30 percent of total farm assets and provide a little over 25 percent of total farm sales. In an attempt to utilize all three concepts of the small farm definition, Crenik (7) concluded that the number of farms classified as small would be reduced by about 40 percent from the number obtained in using median nonmetropolitan family income as the criterion.

The USDA definition of small farms suggests that family members make two basic contributions: physical and financial; however, the family also contributes in other ways. Presently, it is not known what the contributions are of farm families. Until these are properly identified, recorded, and analyzed, the economic and emotional impact of these contributions are only estimated. For example, the physical contributions of the farm operator are known to occur, but the skills, time, and other requirements are not documented. Research on task participation by the spouse has begun, but only for large categories of work areas such as fieldwork and barn chores. Even less information is available about the work efforts of farm children.

Limited research provides some insight to family member contributions. This paper presents highlights from selected research projects on family goals, decision-making, task involvement, off-farm employment, and the emotional support of family members for the farm production unit. The contributions of farm families are not always of benefit to the farm or family. Depending upon the circumstances, individuals involved, and management capabilities, these contributions can become liabilities. The family farm operation cannot always easily change these liabilities. For example, a family member with a poor quality of labor or managerial skills cannot be fired or easily replaced as in other firms. Another example can be cited where family members cannot handle the stress of an insecure financial situation that results when weather destroys a field of crops. Often the emotional strength of the family becomes the determining factor in whether or not the family gives up its farming goals and enters a more financially secure occupation.

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[2] Another small farm definition authorized by the amended Rural Development Act of 1972, PL 95-113, is used in certain research and extension programs. This definition identified small farms as all farms selling less than $20,000 in farm products. This definition places emphasis on the farm business but does not distinguish between families of low or moderate income (4).

[3] This small farm definition is preferred by social scientists, but rarely used because of difficulty in measurement and availability of data. Research findings presented throughout this paper use different definitions as defined by the various researchers in their respective reports.

Contributions Of The Farm Family

Small Farm Family Goals

Goals of New Mexico small farm families were categorized into concepts to compare the relative importance of family and farm goals. The results (11) indicated that quality of life ranked the highest in both family and agricultural goals. Income ranked second among both farm and family goals, followed by the goal category of net worth. Another report using this New Mexico data (8) concluded that a rural-farm lifestyle is desired by small farm families and that small farms are not operated by a residual, deprived, or impoverished group with unduly limited occupational alternatives, as is so often believed. In part-time farm operations, level of debt is kept low no matter what happens to the farm. Using off-farm income to minimize risk in farming, part-time farm families were found to be less vulnerable, than full-time operators, to bad weather, farm price fluctuations, or limited credit.

Decision-Making and Task Involvement

Apparently, small farm families set goals for an attainable farm lifestyle with importance placed on the quality of life that farming provides. How the farm family implements these goals through decision-making and participation in household and farm chores is of major importance, especially on the limited resource small farm.

Using 1970 data collected from 57 commercial strawberry-producing couples in British Columbia, Sawer (21) found that the wife's participation in general farm decisions was strongly related to the wife's involvement in farm tasks. Sawer found that farm size was negatively correlated with general farm decision making by the wife and the wife's involvement in farm tasks, implying that wives on small farms are actively involved in making decisions and performing farm tasks.

Data were collected from 510 Wisconsin farm families in 1962 and were used by Smith (22) and Wilkening and Bharadwaj (29, 30, 31) to analyze the interrelationships of decision-making and task involvement for the farm and household. Smith categorized the task performance and decision-making as to husband dominated, wife dominated, syncratic (more sharing than independent performance of tasks and decision-making) or autonomic (nearly a balance between the spouses). Dominance by the husband over the farm family's decisions was not found. The husband dominated farm operation decisions, while the wife dominated food and entertainment decisions. The division of labor in the farm family was more sharply pronounced than was the division of authority. Field work tasks were performed by the husband, while the wife did most of the domestic and financial tasks. Autonomic behavior was found for barn chores and household maintenance. Socialization tasks were categorized as syncratic. The data suggested that while farm wives assist their husbands in various aspects of the farm, they receive less reciprocal help from their husbands in household and family tasks.

Using data from a 1978 survey of 616 farm families, Wilkening (27) compared his findings to the previously reported studies that used the 1962 data of 510 Wisconsin farm families. Slightly more women in Wisconsin were involved in field work in 1978 as compared to 1962. Almost half of the women in 1978 reported that they did most of the keeping of farm records and paying of the bills. The wife assumed the entire responsibility for household tasks and child care and the majority of the responsibility for gardening and food preservation. The range of the wife's tasks have increased in the farm area since 1962; however, this was not matched by the husband's involvement in additional household tasks. Fewer wives were involved in farm business decisions than in 1962, indicating that major farm decisions are considered business decisions and are not regarded as a family matter. Wilkening believes this may show a shift toward profitmaking and a deemphasis on family needs and interests. The wife is involved in farm decisions that involve her time and effort, such as recordkeeping and employment off the farm. Indications were in the 1978 data that unless the farm wife is equally involved in farm tasks, she is not likely to be involved in farm management decisions. When asked in 1978 how satisfied the couples were with the way they made decisions, settled differences, and divided responsibilities, fewer wives than husbands were "completely satisfied."

Involvement in farm tasks by the wife on dairy farms, during off-farm employment, and through the stages of family life cycle was studied by Wilkening and Ahrens (28) using the 1978 Wisconsin farm data. Conclusions were that wives on dairy farms (two-thirds of the survey) contribute more in farm work than they do on nondairy farms. After the farm reaches a particular size, either hired labor is used, thereby reducing the wife's involvement in farm tasks, or the wife becomes more of an equal partner in the farm operation. Off-farm employment of the husband was found to create a greater need for the wife's involvement only when other variables were controlled. When the wife was employed off the farm, she decreased her farm chores and field work; however, off-farm employment did not change her responsibility for keeping the farm records. In early stages of the family life cycle, it was found that the wife is more involved in farm work than in later stages. Perhaps when she is physically able to do farm work, the wife responds to needs of the farm enterprise as the financial needs of the family expand. As she becomes older and less physically able to do heavy work, the children are older and begin working on the farm.

In a survey of the Missouri Small Farm Family Program participants (9), the analysis of homemaker responses indicated that almost three-fourths assisted with outside chores. Of the homemakers, 45 percent said they helped everyday, 1 percent helped only on weekends, and 32 percent assisted only when the need arose. The remaining 22 percent had no response. When asked about receiving help from the family with household chores, 58 percent responded that they received help: 26 percent received help daily, 2 percent received help only on weekends, and 30 percent received help only when the need arose. It appears that homemakers are assisting with farm work to a greater extent than they receive reciprocal help with household work. Since 71 percent of the homemakers did not work off the farm, the researchers felt that these homemakers may be managing and supervising the farm operation.

A recent national USDA study (16) of farm women[4] lends support to the findings of the studies in British Columbia, Wisconsin, and Missouri. Women of all farm operation sizes were found to be actively involved in farming tasks and involved in farm related decisions.[5] This involvement on the farm was so extensive that 55 percent of the women considered themselves main operators of their farms, with 60 percent of the married farm women reporting that they could run their operations without their husbands.

The proportion of farm women performing a task depended on the nature of the task (see table 1). As a regular duty, women reported doing household tasks (97 percent), taking care of a vegetable garden or animals for the family's food consumption (74 percent), looking after children (74 percent), keeping financial records (61 percent), and running farm errands (47 percent). Over half of the farm women reported at least occasionally taking care of farm animals; harvesting crops or other products, including running machinery or trucks; and supervising the farmwork of other family members. Since this study is National in scope, regional variations in task performance could be examined for the first time. Farm women in the South were likely to report doing fewer farm tasks than women in the other regions of the 48 conterminous states. Significant differences were also found with respect to age of the farm women. A curvilinear relationship was found: Women increase their farm involvement during the ages when children are growing up, and reduce their farm involvement over the ages when their children are grown and when their own strength could be less.

The farm women were asked in the 1980 national survey about family decision patterns for six basic farm management decisions and three household decisions (see table 2). For each type of decision, respondents stated whether they usually made the final decision themselves, their spouses or someone else (for unmarried respondents) made the decision, or they reached a final decision jointly with their spouses or someone else. Less than 5 percent of the farm women reported making a farm decision by themselves. Over 50 percent of the women reported that the husband or someone else was the final authority for decisions concerning the purchase of farm equipment, new production, marketing of products, and attempting a new production practice. Substantial proportions, however, reported sharing decision authority in the farm area. For decisions concerning the household, the majority of the women reported joint decision-making. More women than men had sole authority over household decisions. In the decision concerning off-farm employment of the woman, 41 percent of the farm women made this decision by themselves, with 7 percent of the spouses making the decision and 52 percent of the off-farm employment decisions made jointly. Inquiry as to the farm women's desires to have more responsibility for decision-making indicated that about 10 percent wanted more, while approximately 90 percent felt they had the right amount of responsibility.

A strong positive association was found between involvement in farm tasks and decision-making by farm women in the USDA study. Therefore, the patterns of decision-making over regions and age were similar to those found for farm task involvement. Apparently, farm women who have a legal relationship to the land are more involved with the farm operation. Women with their names on deeds or leases to their land make more farm decisions singly and jointly than those who do not have a legal relationship. The women whose names appear on titles or leases to the land are also involved in a greater proportion of tasks on their operations.

Involvement of children in farm tasks has always been important to farm families. Before the introduction of advanced technology, a large family with many male children meant that the farm could expand. The introduction of public education in rural areas caused a resource allocation problem for farm families with teenage children. Using 1960 census data, Rosenzweig (19) found that apparently school enrollment of teenagers is greater when farm families perceive schooling as increasing the efficiency of technological adaptation on the farm, than when families do not have this perception. Also, it was found that when wage rates for agricultural laborers increase, educated farm children become substitutes for hired laborers, and/or the higher wage rates enable farm children to finance their schooling by working off the farm during school vacations.

In a 1976 study of Iowa farm work (14), children were found to be a source of farm labor for many

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[4] Slightly over 2,500 farm women responded to a telephone interview in the summer of 1980. These women were associated with farms or ranches which were in operation since 1978.

[5] The percentages reported in the following discussion and tables 1 and 2 were calculated for the farming operations in which the respondents reported the task or decision as appropriate. For example, farm women who did not report livestock on their operation were excluded from the task of caring for farm animals.

Table 1.--Women's Involvement in Farm and Household Tasks

Tasks	Regular duty	Occasionally	Never	Total	N[1]
	--------Percent--------				
FARM					
Plowing, disking, cultivating or planting	11	26	63	100	2,257
Applying fertilizers, herbicides, or insecticides	5	12	83	100	2,377
Doing other field work without machinery	17	25	58	100	2,281
Harvesting crops or other products, including running machinery or trucks	22	29	49	100	2,351
Taking care of farm animals, including herding or milking dairy cattle	37	29	34	100	1,944
Running farm errands, such as picking up repair parts or supplies	47	38	15	100	2,483
Making major purchases of farm or ranch supplies and equipment	14	23	63	100	2,455
Marketing farm products--that is, dealing with wholesale buyers or selling directly to consumers	15	18	67	100	2,380
Bookkeeping, maintaining records, paying bills, or preparing tax forms for the operation	61	17	22	100	2,489
Supervising the farm work of other family members	24	26	50	100	2,060
Supervising the work of hired farm labor	11	25	64	100	1,643
HOUSEHOLD					
Taking care of a vegetable garden or animals for family consumption	74	14	12	100	2,350
Doing household tasks like preparing meals, housecleaning	97	2	1	100	2,499
Looking after children	74	13	13	100	1,846
Working on a family or in-home business other than farm or ranch work	34	13	53	100	1,139

[1] All respondents (2,509) are not included. Respondents who reported that a particular task was not done on the farm operation or for their household were excluded.

Source: Jones, C. and R. S. Rosenfeld, 1981. American Farm Women: Findings From a National Survey. NORC Report No. 130. 238p. (p.18). National Opinion Research Center, Chicago, Ill.

Table 2.--Women's Involvement in Farm and Household Decision-Making

Item	Usually the farm woman	Usually husband or someone else	Both together	Total	N[1]
Who usually makes final decisions about the-----	-----------------Percent-----------------				
FARM					
Whether to buy or sell land?----------------	3	39	58	100	2,166
Whether to rent more or less land?----------	2	48	50	100	1,915
Whether to buy major farm equipment?--------	2	52	46	100	2,426
Whether to produce something new such as a crop or a new breed or type of livestock?-	3	58	39	100	2,174
When to sell products?----------------------	4	60	36	100	2,349
Whether to try a new production practice?---	3	62	35	100	2,125
HOUSEHOLD					
When to make household repairs?-------------	24	14	62	100	2,468
Whether to buy major household appliances?--	22	4	74	100	2,481
Whether you take a job off the farm/ ranch?------------------------------------	41	7	52	100	1,959

[1] All respondents (2,509) are not included. Respondents who reported that a particular type of decision had not been made for their farm operation or household were excluded.

Source: Jones, C. and R. S. Rosenfeld, 1981. American Farm Women: Findings From a National Survey. NORC Report No. 130. 238p. (p.29). National Opinion Research Center, Chicago, Ill.

of the farms. One-half of the farms in the study had children 10 years of age or older with 64 percent of these farms reporting that at least one child worked on the farm more than 100 hours during the year. The average total annual hours of farm work per farm with children 10 years or older was 1,821. The average number of hours of farm work by the farm operator was 2,648. Almost three-fourths of the farms reported that the wife did farm work in 1976. The average annual hours of farm work (excluding household work) by the wife was 690, with the wife's work concentrated in the spring and fall.

Off-Farm Employment

Family members not only contribute through goal setting, decision-making, and task involvement; they make financial contributions through off-farm employment. Since 1967 off-farm income has been greater for farm operator families than their net farm income, with the exception of 1973 (26). The dependency on off-farm income for small farms in 1980 is shown in table 3.

Off-farm income provides substantial financial support for small farm families. A study of eastern Nebraska farm families (15) found that off-farm income was greater in magnitude for small farming operations than for other size operations. There tended to be income equalization across farm sizes when nonfarm income was included. When questioned, farm families responded that off-farm work allowed them to remain on the farm and still achieve certain family needs or desires. Lange and Huffman (17) studied farm labor and market labor of both farm spouses and found that one spouse will do the farm tasks of the employed spouse if one is employed off the farm. In analyzing off-farm income, Carlin and Ghelfi (5) concluded:

> Off-farm work by farm operators, while increasing family income, affects the day-to-day farming operation. The farm family must allocate its labor between farming and off-farm employment.... Thus part-time farmers must adjust their farm enterprises to the off-farm labor requirements.

The USDA survey of farm women in 1980 provides the most recent indepth data on off-farm employment of men and women. At the time of the survey, 31 percent of the women held a job off the farm, while 15 percent worked at a family business other than the farm. About 70 percent of the employed women were white collar workers, while 44 percent of the employed farm men held white collar jobs. Among those with current or recent employment, 41 percent of the women worked 40 hours a week, 49 percent worked less than 40 hours, and 10 percent worked more than the normal work week. Among the men, 53 percent worked 40 hours a week, 17 percent worked less than 40 hours, and 40 percent worked more. Thus, over half the women and over three-fourths of the men were working with off-farm jobs at least 40 hours per week. In general, the employed farm women did not differ from unemployed farm women in the proportion of types of farm tasks or farm decisions in which they are

Table 3.--Farm Family Income by Farm Sales

Farms with sales of	Net farm income before inventory adjustments	Off-farm income	Total income
All farms-------------------------	$9,002	$14,820	$23,822
less than $2,500------------------	1,821	20,242	22,063
$2,500 to $4,999------------------	1,582	20,156	21,738
$5,000 to $9,999------------------	2,512	16,768	19,280
$10,000 to $19,999----------------	4,299	12,847	17,146
$20,000 to $39,999----------------	8,280	9,358	17,638
$40,000 and over------------------	24,009	10,042	34,051

Source: U.S. Department of Agriculture, Economics and Statistics Service, 1981. Economic Indicators of the Farm Sector: Income and Balance Sheet Statistics, 1980. Statistical Bulletin No. 674. 156p. (p.106).

involved. Over half of the women stated they worked off the farm because they needed the money. Of these women slightly less than half mentioned farm expenses as one of the financial reasons for this need. As with the other studies mentioned, those families in this survey with a smaller net farm income received a greater proportion of their family income from off-farm employment.

Emotional Support

The strain of allocating labor between the farm, the household, and off-farm employment creates a stressful situation for the family. In ranking occupations according to the incidence of stress-related diseases for each of 130 occupations, the National Institute for Occupational Safety and Health (23) ranked farming tenth. Natural catastrophies, farming problems, and family problems contribute to the stress of farming. Stressful situations are compounded when the farm husband spends 10 to 12 hours per day working on the farm and has little energy or time to handle family crises or to help with child care (24). Also, when the family and farm are dependent on the same resources, the strain of certain situations becomes greater. Unpaid farm bills threaten the livlihood of the family and places extreme stress on the family members.

Although usually an asset of the farm family, the close proximity of the family to the husband's work location can quickly create stress for family members. The husband may need assistance with a small task, thereby requiring a family member to stop his activity and provide the needed help. This can create a stressful situation when the continuity of one's work is broken to aid another.

The emotional health of the farm family can affect both the family and farm. The family members need strong personal relationships within the kinship network. For example, it is relatively simple for employment directions to be given to hired help; it becomes more difficult to tell parents, spouses, and siblings what should be done (13).

Often the farm production unit feels the full impact of emotional discord within the family. Divorce may disolve the farm production unit as well as the family unit when the farm enterprise is divided to meet the interests of both parties.

Assets or Liabilities?

Farm family members contribute in many additional ways other than those presented in the previous literature review. Thus far, researchers have identified goal setting, decision-making, task involvement, off-farm employment, and the emotional support of family members as areas of study. Analysis of family members' contributions, therefore, are limited to these specific areas of research.

It is desirable to analyze these contributions to determine if they are beneficial to the farm and/or family. Contributions imply a positive affect; however, as further analysis indicates, these may be costly to either the farm unit or the family unit. Before family members' contributions can be analyzed, a method of classification must be determined. First, the contributions can be accounted to both the farm and the family (see table 4). The interdependence of the resources for both the family and farm units allow the contributions to be accounted to both statements. What may be an asset for one unit does not necessarily imply it will be a liability to the other. Second, to be an asset the contribution must either increase the family's or farm's resources (for material contributions) or provide a supportive environment to facilitate the function of the unit (for nonmaterial contributions). If it decreases the resources or lends a negative, conflicting environment, the contribution is considered a liability.

Small farm family goals, according to the New Mexico studies, appear to be in the same priority for both the family and the farm. This agreement provides a supportive environment and is therefore classified as an asset. If they differed, the conflict in purpose would be a liability to both the farm and the family.

What small farm families do to achieve their

Table 4.--The Family and Farm Accounts

Contributions	Family		Farm	
	Assets	Liabilities	Assets	Liabilities
Goal setting	✓		✓	
Decision making[1]				
Wife's farm work		✓	✓	
Education of children	✓(income)		✓(technology) ✓(income)	
Off-farm employment	✓(income)	✓(productivity)	✓(income)	✓(productivity) ✓(limited type of production unit)
Emotional support	✓(if +)	✓(if -)	✓(if +)	✓(if -)

[1] It is more appropriate to classify decision-making on a case by case basis, since one particular division of management decisions may be an asset to one family but a liability to another.

goals exemplifies the dilemma of classifying assets and liabilities. Studies on decision-making of the spouses indicate that the farm husbands make farm operation decisions, the wife dominates the household decisions, and joint decisions occur in shared areas of interest and concern. Is this particular division of management decisions an asset or liability? It could be either. Effective and efficient decision-making can be made by many various combinations of family members, depending on their capabilities. Only on a case by case basis can a determination be made as to which division of authority is best.

In many of the research studies, implications were drawn that farm wives do farm tasks without reciprocal help from their husbands in household chores. As women devote more time to farm labor, the addition of this resource becomes an asset for the farm but a liability to the household as less time is devoted to the care of the family and the home.

No longer in our technically advanced culture does the addition of children to the farm family become an asset to both farm and household production. It appears that if educated children can transfer the adoption of technology to the farm, they are more valuable to the farm while attending school rather than while laboring on the farm. This transfer of knowledge can assist in the efficient use of resources. Also, if educated children can obtain additional capital in the form of off-farm income, they are assets for both the farm and family. The Iowa farm study does indicate a large labor contribution by children. This is an average for all children over 10 years of age on the farm and may include adult children, construing the importance of the farm labor contribution of young children. National research is needed to determine the impact of family's labor, including children of all ages, on the family farm.

As indicated in the 1979 farm income statistics, off-farm income is very important to the economic well-being of small farm families. Regardless of who is employed off the farm, one spouse replaces the other in farm labor, thereby reducing both farm and household production. Further complicating the situation, farm production on the part-time small farm may be restricted by the type of operation that can adjust to off-farm employment. Many small farm families, however, may not be able to supplement their income with off-farm employment. Some families may not be located near employment areas, or if employment is available, it may be low wage work that does not adequately utilize the skills, education, or experience of the rural farm population. Even if rural employment in the area is adequate, a certain proportion of the farm population may not be able to participate because of age, poor health, or other personal characteristics. Although over half of the women in the 1980 study indicated they worked off the farm because of financial need, other farm women may be employed off the farm as a result of an emerging lifestyle in which women are pursuing their own careers. Is off-farm income an asset for small farms? Research does not answer this question. Many families participate in off-farm employment and they appear to rely on it economically; however, one must consider the consequences for both the farm and the family that result from the absence of the spouse(s).

The emotional support by the family members can be an asset to both family and farm, if the family can cope with the stress of farming. If the members do not have strong supportive relationships with each other and toward the operation of the farm, both the family and the farm will suffer.

Research Needs

In addressing research needs for the topic of family member involvement on small farms, it is evident that adequate data need to be collected concerning small farm families at the local, State, and national levels. The majority of small farm family research is conducted at the State level. Difficulties arise when these research findings are applied to populations beyond the sample area. Differences in definitions of small farms and type of farming operations throughout the nation make this problem even more pronounced. For example, the goals of the New Mexico small farm families were ranked with quality of life first followed by income (11), while in Wisconsin a reverse of this was noted (27). Until adequate national surveys are conducted, the applicability from one area to another can only be surmised. The most recent national study of farm women included all farm families. Very few small farm women were interviewed, thereby limiting the applicability of the data to small farms.

There are many more areas of small farm living that need study than those identified in this paper. Research on small farm families is needed in three basic areas: (1) Consumption patterns of small farm families. Information is available on the income of these families, but limited information is available about their expenditures. What is the rural cost of living for these families? (2) Long and short term goals of small farm families. Why do they choose this lifestyle? Do they want a different lifestyle, but can't change it? Do they want to farm full time and not work off the farm? How do families make efficient and effective decisions? Basically, do small farm families actually choose this lifestyle, and if so, what sacrifices do they make to keep it? (3) Employment off the farm. With the majority of income on small farms coming from off-farm sources, how does this affect the family's consumption pattern, standard of living, and quality of life? Are these changes desirable? Who supports whom: the farm or the off-farm jobs? Researchers have good ideas for the answers to these questions, but they are only educated guesses until adequate data are collected and analyzed.

Agricultural extension programs assist small farm families; however, their effectiveness is limited when the full potential of family members' contributions is not known. Knowledge is very limited about the motivations, skills, finances, labor, and other important aspects of small farm families. In developing effective extension programs for these clientel, educators need to know what specific training is needed to improve the contributions of family members in the management and operation of today's highly technical farm enterprise. States have many programs for assisting small farm families.

In Pennsylvania, extension agents work with small farm families in developing farm vacation enterprises. Documentation of these efforts (3) indicate that few families keep adequate financial records of gross farm-vacation income. Apparently these enterprises provide small additional cash incomes needed to make the farm business support itself and contribute somewhat toward the improvement of farm family living.

A joint effort between USDA, ACTION, and the North Dakota State Economic Opportunity Office has placed VISTA volunteers in the North Dakota small farm program. These locally recruited, retired farmers and USDA employees, and rural residents meet with small farm operators to discuss their problems and propose solutions. The program appears to be successful according to the report following the first year (18).

Missouri has had a successful program for small farms since 1976. The small farm programs are responsive to the needs of the participants. For example, in the Meramec area (10) training was given by the Internal Revenue Service to the small farm paraprofessionals. The results were mixed but all the small farm families were unaware that Extension could offer this type of service. By completing their own tax forms, small farm families could increase their disposable income and use it more effectively in other areas of the farm operation.

Trish Sachs of the Massachusetts Extension Service works with field staff who provide educational programs for small farm families. In personal correspondence (20) about her work in developing cottage industries, she probably expresses the reason for limited research on small farms. She writes, "I'd like to do some research ...but my time is limited to working with over 50 field staff in Extension." The success of her programs in Massachusetts indicates the real potential for developing the skills of farm families. Research could enable State programs to identify program areas and document their success in furthering the efforts to improve the quality of small farm family living.

Summary

The contributions of farm families are best summarized by Judith Bortner Heffernan (12) in a statement made before a regional small farms hearing.

> ...I see farm women and farm families capitalizing the family farm by their off-farm labor; I see them fully involved in decisions about the farming operation; I see them providing an indispensable support system for farming in the form of "running and fetching" hot meals, spare parts, more fuel, another load; I see 700 of them completing the UMC [University of Missouri--Columbia] short course called Feminine Farrowing School; I see farm women providing the support for rural communities, promoting agricultural products, perpetuating in their children the values

of family farming, suffering the stress of high debt load and uncertain harvests and markets. I also see farm women not being recognized before the law or before the society as equal partners in the farming operation with their spouses. I see much that farm families do being ignored, minimized or undervalued.

Since her statement in December of 1979, some important changes have begun to occur. Recent legal actions indicate a change of attitude toward the contributions of farm families. The Economic Recovery Tax Act of 1981, PL 97-34, allows the estate of one spouse to pass to the other without taxation. In the next three years tax rates applying to estates below $600,000 will be eliminated in this new legislation. The transfer of small farms from one generation to the next can be accomplished, whereas, before the legislation part of the farm usually had to be sold to pay estate taxes. Legal recognition of the contributions of farm family members has begun. This is just a beginning. As the old Hoosier farmer would say, many more furrows need to be turned before the day's work is done.

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MARKETING FOR SMALL FARMERS - A QUESTION OF LIMITED ALTERNATIVES

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ABSTRACT

Marketing is a critical factor, particularly to those farmers having limitations upon land, capital and management. Farmers with these kinds of limitations are operating with large risks. An adequate job of marketing can help reduce those risks. The ability of producers to develop a working knowledge of marketing alternatives is essential to success. The belief that food sells itself leads to production plans which may leave the farmer with unsold merchandise, or at best, selling at distressed prices. Farmers have thought of the production process as tangibles and of marketing problems as intangibles. This paper attempts to evaluate actual and potential marketing alternatives for small farmers and make recommendations for additional research needs.

Keywords: Consumer characteristics, direct marketing, marketing, pick-your-own, roadside markets, small farmers.

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INTRODUCTION

The marketing of agricultural products plays a vital part in all our lives and engages a wide variety of skills. Its continually changing processes are evidence of the ingenuity of man finding better ways of satisfying the varied demands of consumers.

In addition, the American buying public is changing in various demographic and attitudinal dimensions, all of which will affect its buying behaviors and eating habits. The above comments are usually reserved for large scale marketing systems and production units. However, the same principles apply to small farm operations, the difference being that such operations are more localized.

Unfortunately, too many times the farmers' production plan is formulated without an appropriate marketing plan. The consequences of such decisions can only lead to disappointment. The belief that food sells itself leads to production plans which may leave the farmer with unsold merchandise or at best, selling at distressed prices. Historically, farmers have thought of the production process as tangibles and of marketing problems as intangibles.

OBJECTIVES

The objectives of this paper are twofold:

1. To evaluate actual and potential marketing alternatives for small farm operators.
2. To make recommendations for additional research for marketing systems that may prove useful to small farm operators.

MARKETING DEFINED

Marketing is defined for the purposes of this paper as follows: 1) ascertaining the needs and wants of markets (consumers); 2) planning product availability; 3) effecting transfer in ownership of products; 4) providing for their physical distribution and 5) providing for the appropriate facilitating functions to facilitate the entire marketing system (credit, etc.).

MARKETING ALTERNATIVES FOR SMALL FARMERS

For the purpose of this discussion, we are going to limit the scope of this section to direct marketing of fruits and vegetables. Direct marketing is the marketing method whereby farm products are sold by the farmer to the consumer. Direct marketing oftentimes enables the farmer to obtain a higher price for the commodity produced and offers the consumer fresh, quality products. While it is generally accepted that the U.S. food marketing system performs a number of essential services in an efficient manner, it is also recognized that alternative food distribution systems may be useful. Direct marketing is one alternative food distributing concept that has gained popularity in recent years, representing 2 percent of total farm sales in 1980. Alternative marketing systems and the extent of directness are summarized in Figure 1.

PICK-YOUR-OWN

The "U-pick" or "pick-your-own" method of direct marketing is the most direct of the marketing alternatives. Pick-your-own operations enable retail customers to harvest their own agricultural products from the producers' field. Having gained in popularity in recent years, PYO is not a new marketing concept. Its roots date back to the early 1950's in some states and to the 1920's - 30's in others. Producers find that PYO compliments other marketing methods and provides partial solutions to the problems of increasing marketing costs and unavailability of harvest labor. As food prices rise, customers view PYO as an alternative way to obtain quantities of fresh fruits and vegetables at lower costs. There is also a form of nostalgia associated with PYO, providing a form of recreation and an opportunity to satisfy a renewed interest in rural-urban relationships concerning food production. (1)

Pick-your-own marketing is not for every grower. When produce is marketed via this method, the farmer becomes a retailer. As such, he is confronted with many of the same problems (including dealing with the general public) that all retailers face. Many farmers have neither the temperament nor the desire to assume their retailing functions. However, for those who do, this method of marketing is an alternative that should be considered. (2)

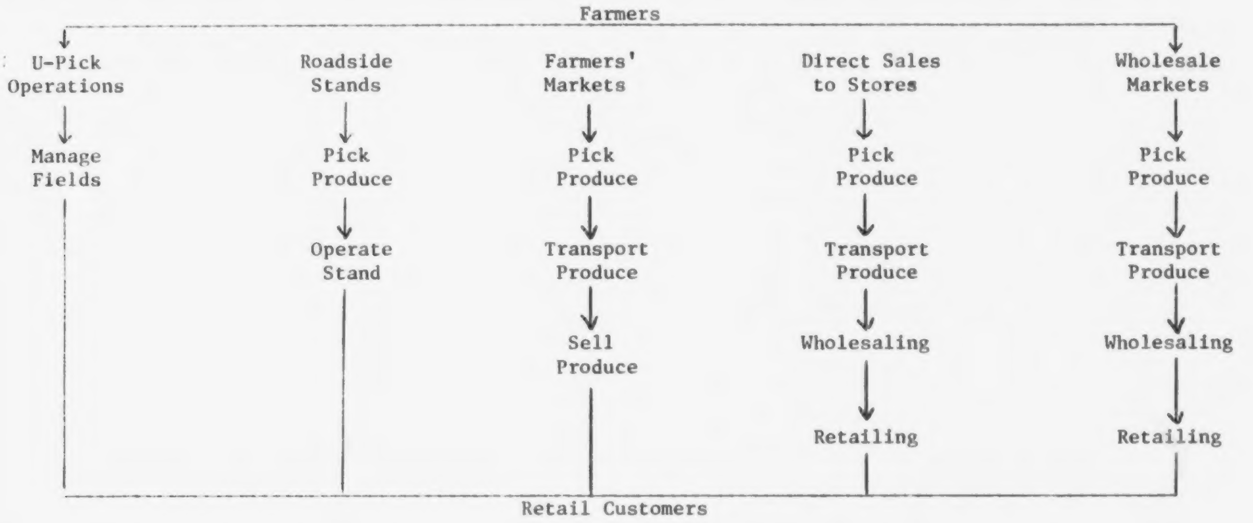
ROADSIDE MARKETS

Roadside marketing affords growers the opportunity of recouping some of the costs of marketing, for example, commission fees and transportation costs. This marketing method has been called the most lucrative of all direct marketing outlets and is sometimes used along with pick-your-own operations. Roadside stands/on-farm marketing have a wide variety of styles and applications. Facilities range from a simple stand with a few seasonal fresh items to permanent enclosed structures on the scale of medium-sized supermarkets. The need for transporting products to the market is eliminated for the most part (although other transport costs may be incurred if additional items are purchased elsewhere). Packaging and handling costs are greatly reduced when compared to those of supermarkets. (3)

The roadside market is the most capital-intense of the direct marketing methods. Facilities, equipment and utilities are generally required. Markets must be planned to fit an individual's current needs and still be adaptable for expansion.

Roadside markets are said to offer a welcome alternative to the canned glitter of the shopping mall and the sterile sameness of supermarkets. But the successful roadside market doesn't just happen. Thorough planning must precede the establishment of such a business. Once established, a roadside market, regardless of size, must be managed astutely, skillfully and shrewdly. There can be no let up in the managerial process. (4)

Figure 1. Alternative market systems and relative directness to the retail customer.[3]



FARMERS' MARKET

A farmers' market is basically a direct outlet for locally grown farm produce. This method requires the farmer to harvest the produce, transport it to the customer and operate the retail selling aspect of the venture, usually in the form of tailgating from the back of a pick-up. The goal of a farmers' market is to provide a place where growers can sell fresh produce to consumers and a place where fresh fruits and vegetables can be bought in quantities suited to the needs of most customers. (5)

DIRECT SALES AND WHOLESALE MARKETS

Direct sales to stores, sometimes referred to as institutional sales, offers the producer one more link in the chain of alternatives necessary for many to do an adequate job of marketing. It is important to note that it is the use of a combination of many of the alternatives discussed that is helping to keep many a small farmer financially solvent today. Harvesting, transportation and commission fees (depending upon sales entry level) are inherent to direct sales to stores. Wholesale markets afford the grower involved in direct marketing an opportunity to move large volumes of produce that are not able to be marketed directly due to peak periods in the production and harvesting process. A producer generally exits the wholesale market alternative at the wholesale price level.

Direct marketing methods combined make up a very small portion of total dollars spent on food moving through the distribution system. Retail chains have managed to stave off any initial threats that direct marketing movement may have portrayed. The future, then, of direct marketing depends in large part upon the demand for this type of marketing method to continue. Some geographical locations are well suited to the concept of direct marketing, while other areas are not.

Perhaps we can get a better handle on research needed concerning the small farmers' marketing plight if we consider the benefits, problems, limitations and potential barriers to direct marketing.

PRODUCER BENEFITS AND PROBLEMS ASSOCIATED WITH DIRECT MARKETING

The primary benefits to U-pick operations include reduction and/or elimination of harvest labor, elimination of harvest transport costs, limited capital investment required for initiating, no storage, no grading, large sales per customer and no commission fees. Problems involved with running a PYO include liability insurance requirements and costs, uncertainty pertaining to the availability and supply of fuel, weather patterns during peak harvest, field management, including customer check-in and check-out and potential damage to personal property/growing crops. Barriers to entry and operation of a pick-your-own include limited demand in sparsely populated areas, limited crops suitable to this method of marketing, seasonality of production, location of the operation in regard to potential customers and the need and requirement for adequate field supervision. As with roadside marketing and farmers' markets, the operator/sales agent must like dealing with the general public, a possible barrier. The PYO direct marketing alternative, a type of vertically integrated operation, requires top level managerial ability to be successful.

Roadside markets offer the producer more flexibility in regard to having adequate quantities of variety on hand for the consumers. Primary benefits include transportation costs being reduced and perhaps eliminated, little direct competition, less shrink involved in handling produce, large sales per customer, reduced packaging costs and no commission fees. Some of the problems associated with this method of marketing include being capital intensive, sales labor force required, affected by fuel shortages, weather patterns, advertising and promotion costs, some storage is required and you have added handling costs over pick-your-own. Barriers to entry are somewhat similar to those for pick-your-own. Additionally, they include location and zoning, limited demand due to population size, road access and parking, and lack of marketing management expertise.

Farmers' markets are generally favored by the smaller or limited resource version of the small farmer. The benefits associated with farmers' markets include very little capital investment for facilities (a truck and selling area are usually required), reduced packaging, advertising and promotion costs, flexibility in that several market locations are possible, support generally obtained from community organizations, accepts small volume and limited variety of produce. Inherent problems are concerned with transportation costs, need for sales labor, consumption of operators time per unit of sales, storage and handling, direct competition, smaller sales per customer and rental fees for the stall or selling space. Barriers to entry and operation, based upon experience of our extension marketing personnel, of a successful farmers' market are complex. Zoning restrictions and municipal ordinances must be dealt with. Conflicting goals of the organizers and users can, at times, block a potentially successful venture from getting started or surviving. Also, depending upon the structure and the involvement of community support, a market manager may be required. Availability of produce and a lack of marketing expertise, specifically in the pricing area, have also been found to be potential barriers to direct marketing through a farmers' market. (6)

Direct sales to stores are another alternative means of direct marketing. Stores are defined here as retail grocery stores and the restaurant trade. Benefits of this method include the small capital investment required and integration in the sense that the producer is performing more of the marketing functions to deliver the product directly to the user. This should then result in less shrinkage. Generally there are large sales per customer and the producer is able to forego commission fees. Problems associated with direct sales to stores include higher transportation costs, grading standards that must be closely followed, storage and handling is required, and competition is stiff. Barriers to entry are quite similar to those of the more traditional wholesale markets. Volume requirements, bidding and contractual arrangements, seasonality of production in certain producing regions and communication specifically in regard to supply, demand and ultimately pricing are all probable barriers.

Wholesale markets, being more traditional in nature, generally require the producer to ship produce to terminals and/or auction-type market facilities. Many of the benefits and problems are quite similar as those for direct sales to stores, the primary difference being that commission fees are required at wholesale markets. This method usually requires producers to accept prices quoted by the market, though it should be pointed out that wholesale markets help trigger the price discovery mechanism in the produce marketing field, minus the commission fee or cost. A major problem for the small producer lies in being able to consistently derive a large enough volume for this method to be a viable alternative.

All of the marketing alternatives available to the small farmer have not been included in this paper. However, many of the inherent benefits and problems begin to set a pattern and therefore may warrant the attention of researchers and extension personnel in developing viable marketing alternatives for the small producer in the future. Though livestock marketing has not been the center of discussion here, it may be considered as a case in point. Direct-to-packer sales, a form of direct marketing, are making up an ever increasing amount of total pork sales. This method of direct marketing has implications to the pork industry and individual producer that will bring further change over time. The marketing method may be direct but the initial benefits appear to favor the large producer, and the small farmer is found to be at a disadvantage. Currently, one packing company in Delaware buys 73 percent of all market hogs produced, which they buy from 77 percent of both the medium and large producers, yet they buy from only 68 percent of the small producers. (7) The point here is that the other 23 percent of the medium and large producers have other alternatives, but a certain percentage of the remaining 38 percent of small producers is too small for packers to bother dealing with. Another disadvantage of this marketing alternative which must be dealt with is the price discovery mechanism.

PRODUCER MANAGEMENT CONSIDERATIONS CONCERNED WITH MARKETING

Regardless of the marketing method available to the small farmer, other factors, such as management considerations, may be the overriding factor in determining which alternatives a producer can actually use. Marketing is a critical factor, particularly to those farmers having limitations upon land, capital and management. Farmers with these kinds of limitations are operating with large risks. An adequate job of marketing can help reduce and/or eliminate those risks.

Producer management and the ability to develop a working knowledge of marketing alternatives is a problem. This problem oftentimes causes the producer to become a price taker/risk assumer, and therefore, a less-than-efficient operator. For many, time, money and educational support will help/is helping overcome this problem. However, for others, the limitations of land, labor, capitol and management are overriding concerns and controlling forces in their operations. For these producers, marketing is important, but it will take much perserverance and very understandable lenders to bail them out. The problem perpetuates itself, but a well drawn marketing plan can help reduce the limitations of these factors.

Key management considerations of direct marketing require the producer to formulate plans for the organization and operation of a market. These considerations include location, logistics of the market layout (parking, building, equipment, packaging, displaying, selling area), produce line considerations requiring knowledge of market demographic information, bookkeeping/accounting systems, advertising, customer service and pricing. (8) Other factors, such as customer wants and needs and legal aspects, are also most worthy of management consideration. (9)

CONSUMERS AND DIRECT MARKETING

Marketing for small farms is, of course, an important aspect of the entire marketing system. However, we must be careful not to over-emphasize the potential influence. We have heard many times through the last few years that direct marketing will in some way replace supermarkets as a source of the entire food supply, especially in the area of produce.

Direct marketing is an alternative to the predominant outlets such as supermarkets, but is not necessarily a substitute for obvious reasons, at least not at this time.

However, the movement to direct marketing has had some effects on the food retailing industry, such as food stores taking on an atmosphere of farmers' markets. Safeway Stores opened its first "Farmers' Market," a 24,000 square foot unit featuring a very extensive produce inventory. (10) Certainly, supermarket operators consider them limited competition on a local basis and will attempt to compete with them for the consumers food dollar.

DEMOGRAPHIC CHARACTERISTICS

Knowledge of the various characteristics of consumers is important in any successful marketing endeavor. Consumer buying behavior is related to the following characteristics: 1) values and attitudes; 2) emotions; 3) response traits; 4) habitual patterns of behavior; 5) social influences and 6) environment and personal circumstances.

Two of the most important aspects are the age distribution and income level. Each of the various age and income groups generally have specific buyer behavior characteristics. The changing composition of the population is reflected by the data in Table 1. Significant changes are expected within the next 20 years. For instance, the under-40 age group is expected to increase by about 5 million. However, the most significant change will be in the 40 to 64 age group, with an expected increase of about 24 million.

Family size will decrease from 3.3 per household in 1978 to 3.0 by 1990. About 50 percent of all the nations' women currently work outside the home, and that number is expected to increase. Therefore, convenience will be a top priority.

Family income is the second most important consideration. Median family income doubled during the 1970's and reached a total in 1980 of $21,023.

Table 1. U.S. Population Distribution By Age Groups, 1980 and 2000 (11)

Population	Years 1980	2000
	- Millions -	
Under Age 20	72.4	76.7
Ages 20-39	72.4	71.8
Ages 40-64	56.2	80.0
65 and Older	25.5	31.8

Source: U.S. News & World Report, July 20, 1981.

But the purchasing power of a family with that income in 1980 was only $40 more than in 1970.

Statistics on family income groups are shown in Table 2. As indicated, approximately 53 percent of the families had median income exceeding 20,000 dollars.

Table 2. Where Families Stand in Income, United States, 1980. (12)

Family Income	You Fall In Bracket
- Dollars -	- Percent -
75,000 and above	Top 2%
50,000 and above	Top 7%
35,000 and above	Top 20%
25,000 and above	Top 39%
20,000 and above	Top 53%
Less than 15,000	Bottom 33%
Less than 10,000	Bottom 19%
Less than 5,000	Bottom 6%

Source: U.S. News & World Report, August 31, 1981. Based on Median Income in 1980.

The question that must be answered is what can one expect from these various groups in terms of buyer behavior, such as to what extent will they patronize the various market outlets serviced by small farmers.

We do have knowledge of general buying characteristics, and these are as follows: 1) a typical urban-family of 4 spends approximately 24 percent of its income on food; 2) the average weekly bill for food eaten at home has increased by 128 percent in the last decade; 3) many consumers are choosing lower-priced generic brands at the supermarket or buying in one of 800 no-frills warehouse stores; 4) fresh fruits and vegetables average 8 percent of at-home expenditures; 5) fresh vegetables account for 52% of the weekly expenditures of fresh fruit and vegetables; 6) 702 million worth of fruits and vegetables were purchased with food stamps in 1980; and 7) about 80 percent of the produce items for the school lunch program are purchased locally. Thus, there are opportunities, at least on a local basis.

CONSUMER PREFERENCES

Several studies have shown that consumers have a definite pattern of likes and dislikes concerning where to shop for produce, Table 3.

Table 3. Reasons for Shopping at Various Market Types, Delaware. (13, 14)

Reasons	Roadside Markets	Supermarkets
	- Consumer Ratings[a] -	
Quality	2	3
Freshness	1	5
Price	3	1
Location	4	2
Cleanliness	5	4
Large Selection	6	6

Source: Experiment Station Bulletins Nos. 424 and 426, February and September 1978, respectively.

[a] 1 = most important

For example, when comparing consumer preferences for produce at roadside markets with that of supermarkets, there is a distinct difference. Consumers choose produce at roadside markets because of quality instead of price, as at supermarkets. Price is the most important characteristic in the consumer's mind when shopping at supermarkets.

Thus, since quality rates so high, merchandising becomes an important aspect of running a direct market. Unfortunately, too many direct market operators do not heed the need for a sound merchandising program. Consumer motivation is of a dynamic nature and consumer attitudes and values do change over time.

COMPETITIVE ASPECTS OF DIRECT MARKETING

In 1980, total grocery store sales were $220.8 billion, approximately a 10.5 percent increase over 1979. During 1980, about 2 percent of farm sales were classified as direct farmer-to-consumer.

The various new or revitalized market outlets, such as farmers' markets, roadside markets, tailgate and pick-your-own, have not gone unnoticed by the conventional retail trade. There is a renewed emphasis on produce departments.

In a survey of food chain executives, the produce department ranked highest in terms of importance, in contrast to previous years when produce usually ranked third or fourth. Its prominence here has signaled an important trend: the meat department used to be number one.

There are some basis trade facts of which we need to be aware to assess the effectiveness of the above market outlets with other types of food stores. Approximately 10 percent of all grocery stores' sales were of produce. Firms building new stores are making the produce department 1/3 larger, with the average number of items displayed now at 120. Oriental and ethnic vegetables are the fastest growing items within produce departments. Thus, you need to do something different if you intend to attract customers: the market will not necessarily come to you, especially if, in your respective trading area, supermarkets are concerned about the potential competition from direct market outlets.

Each outlet operation should be tailored to its own trading area. In most markets, the reputation or image of a market is markedly different from others. In fact, there are numerous degrees of image identification between those which have a strongly positive image and those whose image puts them at a real competitive disadvantage.

In summary, consumers are attracted to the various market outlets described in this paper. However, there is a limit to the extent of switching from supermarkets to the other alternative marketing outlets. Seasonality, the convenience of one-stop shopping at supermarkets, and the food industries re-emphasis on produce are serious limitations to the full potential of these outlets. One should not be led into the false premises that "over-storing" is not possible with direct outlets.

RESEARCH AND EDUCATIONAL NEEDS

It is important for the researcher and extension personnel to first understand the various marketing problems facing the small farmer before attempting to identify research and educational needs. Observation of and experience with small farmers has led to this partial listing of small farm market research and educational needs.

1. Additional consumer preference studies.

2. Case study analysis of benefits of various marketing alternatives including market pooling. This needs to encompass more products than just fruits and vegetables.

3. Educational programs concerned with marketing alternatives may need to be developed specifically to meet the needs of small farmers. This would entail economics, fundamentals and techniques.

4. Determine the feasibility of contracting for marketing services, since small farmers usually have limited experience, time and access to market information.

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SMALL-FARM WOODLANDS: OTHER FOREST INTERESTS FOR SMALL-SCALE AGRICULTURE

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ABSTRACT

Small-farm woodlands are an important segment of our nation's commercial forest land. Found mostly in the east, they amount to more than 13 million acres. Although most farm woodlot sites are not the best farming sites, many are good for growing timber.

Most farmers probably own their forest land because it came with the farm. While many hold their woodlands for their own use, few seem interested in growing timber. Most, instead, seem more interested in nontimber outputs. Most have a consumer orientation to both the timber output and the nontimber outputs of their woodlands.

In facing problems that are of general concern to all forest owners, farm-woodland owners are usually at some disadvantage to public and industrial owners, yet, usually hold an advantage over other nonindustrial private owners.

Keywords: Available timber, farm wood lots, forest services, forestry assistance, recreation, small farms, timber, timber-harvesting, woodlands.

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FOREST PERSPECTIVE

Nationally

Nonindustrial private forests are important to our nation's timber supply. They account for 58 percent of the commercial forest land in the United States (Table 1). In 1977 they provided about one-half of our nation's total roundwood output--one-third of our softwood timber harvest and three-fourths of our hardwood timber harvest (8).

Table 1.--Area of Commercial Timberland in the United States, by ownership, 1977

Ownership	Area (million acres)
National Forest	89.0
Other Public	47.6
Forest Industry	68.0
Nonindustrial Private	283.1
All owners	487.7

Source: USDA Forest Service (8).

Farm woodlands are an important part of our nonindustrial private woodlands. Clawson (2) estimates that there are about 3 million nonindustrial forest owners in the United States and that between 3/4 and 1 million farms contain commercial forest land. The Census of Agriculture (9) indicates that slightly more than one million farms contain woodlands which, in aggregate, total almost 95 million acres. The USDA Forest Service (8) estimates that 117 million acres of commercial forest are owned by farmers. While the apparent discrepancy, as Binkley (1) suggests, are probably differences in definition, the important thing is that farm woodlands are a substantial part of our nation's forest resource: they represent about ¼ of our nation's commercial forest lands.

Small farms are a significant part of that resource. Almost half of the farms smaller than 500 acres contain woodlots. They account for about 45 million acres. Of the farms with annual sales less than $2,500, more than one-fourth have woodlands. In aggregate those woodlands amount to more than 13 million acres.

Regionally

Although nearly half of our nation's forest land is in the west, much of it is in wilderness areas that are withdrawn from timber utilization. Three-fourths of our commercial forest land, then, is in the east, where it is split rather evenly between the north and the south (Table 2).

In the north commercial forests cover one-fourth of the land area. Through much of the south they occupy more than half of the land area. In the west commercial forests cover little more than 10 percent of the land.

Within each of those three major regions, farm woodlands make up one-third of the privately-owned commercial forest. The south, though, claims nearly half of our nation's farm woodlands.

Locally

Generally forests occupy sites that are either too wet or too rough to cultivate. Because of broad drainage and topographical patterns, we find some rather large concentrations of forest land in the east--the northern portions of the Lake States, the mountain areas of New England and the Middle Atlantic States, the Appalachian Mountains, and the hill country along the Ohio River. Many of the farms in those areas are small.

Although most farm woodlot sites are not the best farming sites, many are good for growing timber. As Clawson (2) emphasizes nonindustrial private forest lands have productive capacities that are generally comparable to National Forest lands. And, in areas where industrial forest lands are concentrated, nonindustrial private lands generally share the higher productive capacity that may have brought the industry into the area.

OWNER PERSPECTIVE

Nationally

Even though nonindustrial private forests are important, we don't really know much about the people who own them. And it is not because we haven't tried.

Since 1940 more than 100 studies have been made on nonindustrial private forest owners to determine such things as typical size of ownership, tenure, occupation, forestry practices, and ownership goals (4). But Royer (5), in reviewing those studies, points out that landowner profiles vary within regions as well as among region. He concludes that, because most of the studies have been fragmented, narrowly focused, and piecemeal, it is difficult to develop continuity across

Table 2.-- Land areas in the United States by region and section, 1977.

Region and Section	Land (million acres)	Forest (million acres)	Commercial Forest (million acres)
North			
New England	40.3	32.5	31.0
Middle Atlantic	87.2	51.8	48.2
Lake States	208.0	53.3	50.0
Central States	291.6	43.2	41.6
Total, North	627.2	180.2	170.8
South			
South Atlantic	76.0	48.7	42.7
East Gulf	71.8	42.3	40.1
Central Gulf	89.2	51.4	51.0
West Gulf	273.8	64.6	49.6
Total, South	510.8	207.1	188.4
West			
Pacific Northwest	466.7	172.3	53.5
Pacific Southwest	104.2	42.1	17.3
Northern Rocky Mtn.	215.2	55.7	33.5
Southern Rocky Mtn.	229.6	82.1	24.3
Total, West	1,125.7	352.2	128.6
Total, All Regions	2,263.5	740.1	487.7

Source: USDA Forest Service (8).

regions and through time for most of the landowner profiles and nearly impossible to aggregate and disaggregate the information provided by the studies. Royer does, though, describe two broad groups of owners--producers and consumers. Producers are profit oriented and strive to maximize the economic outputs from their land. Consumers are utility oriented and define their output interest in nonmarket terms. I will touch on these later.

Regionally

A notable exception among ownership studies is a series of studies being conducted by the Resources Evaluation Unit of the USDA Forest Service, Northeastern Forest Experiment Station. These studies, begun in 1970, are being made in conjunction with and linked to the statewide forest surveys in the northeast. Because the procedures and questionnaires used in the studies are comparable from state to state, the data developed provide continuity across both region and time. They also provide a chance to observe and analyze trends.

To date the owners in twelve states have been canvassed and about 8000 questionnaires have been analyzed. Data for nine of the states have been published; one is in process. Data is being collected in New York and the canvass of Maine is being planned. The Maine study will complete the first round of ownership studies in the fourteen state area. Plans call for re-canvasses to be an on-going part of the Northeastern Station's program.

The ownership studies in the northeast all point to one important fact: there is no "typical" forest owner. Because owners have a variety of backgrounds and interests, we do ourselves a great disservice when we try to come up with a sterotype of the average owner (3).

The northeast ownership studies catalog such things as the occupation, the early life and educational background, and the age and income level of owners, their ownership tenure, how far they live from their forest tracts, why they own them, and their reasons for cutting or not cutting their timber. The studies are aimed at learning about the overall population of private woodland owners--industrial as well as nonindustrial. Although the owners of farm woodlands are only one segment of that population, many of the findings help us to a better understanding of farm-woodland owners.

In the northeastern states canvassed to date, nearly one-fifth of the owners are farmers. They own about one-third of the privately held forest land in those states. But there are some considerable differences from one state to another. In New Hampshire and Vermont, for example, only 5 percent of the owners are farmers. In Kentucky 31 percent are farmers. Although two-thirds of the forest landowners in the northeast have farm or rural backgrounds, three-fourths of those in southern New England were raised in cities.

Why do farmers own their forest land? Most of them probably own it because it came with the farm. Many, though, hold their forest land for domestic use--cutting fence posts or firewood and occasionally selling some timber. Others derive esthetic enjoyment from their woodlands. Some hold their woodlands for recreation and some for investment. Few state that they are holding their woodlands for timber production. And those, generally, are the owners of larger timber tracts. It seems that, using Royer's classification, farmers tend to be consumers rather than producers.

Though few nonindustrial private owners are intent on timber production, many do plan to cut their timber some time in the future. The owners whose stated objective is timber production are, of course, likely to do so. Other large-tract owners may well join their ranks. Those owners who have cut in the past are likely to do so again. Farmers, people who have received forestry assistance, and those with rural backgrounds are also likely to cut (3).

Money, too, is a major reason for cutting timber. Of the owners in the northeast who had sold timber, about a third did so because they needed money. Ten percent cut their timber because they were offered a good price. Twenty percent cut because their "timber was mature." Kingsley suggests that the latter owners were actually motivated by a sense of the value of the timber. As Stone (6) observed, "Many owners have nontimber producing objectives most of the time, but during the short period when their timber is merchantable they are timber value oriented."

Surprisingly, very few owners in the northeast are opposed to cutting. Many of those that are opposed to cutting sense that cutting would destroy the scenery or the value of the land for hunting. Some owners distrust loggers; some are just basically opposed to timber cutting.

Most owners who have not cut any timber reason that their timber is not yet mature (many of them are likely to experience someday the value phenomenon that Stone referred to). Others cite low price and low volume or poor quality timber (many of these owners may have tried, unsuccessfully, to sell some timber). Some tracts have not been cut because they are tied up in estates; others because they are too small to interest loggers.

Very few nonindustrial private forests in the northeast have been cut for timber stand improvement (TSI). And very few private owners have sought forestry assistance. Those that have are, generally, the owners of larger timber tracts. Most owners,--two out of three--do not, apparently, know who to contact for help. Only one-fourth seem to be aware that state agencies and consulting foresters are available to serve them.

SMALL-FARM WOODLAND OWNERS

While we know little about our nation's nonindustrial forest owners, we know less about farm-woodland owners. We can, though, develop some hypotheses based on interpretations from the studies described above, expert opinion, and intuition. Until we aim some studies directly at small-farm woodland owners, that's the best we can do.

We can consider two major areas of concern to woodland owners in general--timber outputs and nontimber outputs--and hypothesize that many small-farm owners are at a disadvantage to public and industrial owners in some ways, yet hold an advantage over other nonindustrial owners in other ways.

Timber Outputs

Markets

The primary role of most public owners is that of land stewardship. Many are charged with multiple-use objectives. Few are required to generate sufficient funds from timber sales to cover the costs of operating the ownership. Most would continue to provide social benefits, regardless of timber market conditions.

Most industrial forests are located where they are for various strategic reasons. They include the existence of markets and the industry's confidence in its strength to develop those markets. But changes in market conditions are also important to industrial owners--changes in demand, changes in tactics by existing competitors, the entry of new ones. So are general changes in economic and business activity. Most industrial owners employ professionals to monitor such changes and make adjustments for them. Most small-farm owners can't.

In some areas timber markets may be weak or lacking. This can pose a real problem to owners who feel the need to sell some timber to meet an emergency. Some may have to accept poor offers because they do not have the time or opportunity to seek better ones. Some may receive no offer at all. Some may be unable to find a potential buyer. While unfortunate, these problems exist.

The farm-woodland owners, though, have an advantage over non-resident owners. Because farmers are part of the local community, they usually have more opportunities than do their city counterparts to assess local timber markets, to seek out prospective buyers, and to negotiate sales. In the sad case where markets simply do not exist, farmer-owners are likely to be aware of that beforehand, thus avoiding disappointment.

Many owners, though, are content and able to wait for markets to develop. Timber keeps fairly well on the stump. But farm owners, in particular, can use some of their timber for posts and firewood while they wait. Other owners, with luck and pluck, make their own markets: the owner with some veneer quality trees may seek out an eager buyer; those with poor quality timber may provide their city cousins with fuel for their woodstoves. Farmers whose woodlots are nearby run a low risk of having their veneer trees being stolen. They seldom encounter logistic problems in running a firewood operation.

Some owners do not need a market. They simply keep their timber for their own use and enjoyment. As part of a farm, the enjoyment is continuous.

Price Information

There are no national services for reporting timber stumpage prices. Few states have them, but most public and industrial owners develop their own.

Timberland owners, then, are at some disadvantage in making timber deals. But, the farmer-owner is better off then the professional person who lives in town, some distance away. The farmer-owner is more apt to be aware of local prices through word-of-mouth. Although stumpage values vary a good bit from one logging chance to another, the farmer-owner is likely to have some idea about the conditions on neighboring properties that have been logged, and thus do a better job in assessing offers for his or her timber.

Part-Time Logging

By definition, nonindustrial private owners lack the facilities to process timber into wood products. But here, too, the farmer has an advantage. Most farmers have tools and equipment that can be used for timber harvesting and hauling and which, through part of the year, are idle. Equally important, they are on site--both the farmer's family and the equipment. Most farmers, then need only to find the time to harvest their timber, transport it to suitable processing facilities, and claim the value added at that point. The time involved can be adapted to other farm schedules. Most nonfarm owners, on the other hand, would need to buy or rent the tools and equipment. For most the cost would be prohibitive. For many, too, so would the time and travel scheduling.

Fuelwood Market

Our expanding fuelwood market may become the single most important development in our nation's forest history: it provides an outlet for small, poor-quality timber.

Historically, one of the major obstacles to intensive timber management has been the lack of markets for the poor-quality material that usually needs to be removed in cleanings and timber stand improvement. In the past such cultural activities involved costs that had to be carried until the stand was harvested. For most small-woodland owners the investments were prohibitive and they generally declined to make them.

Since the mid-seventies our nation's army of woodstove owners has been growing and the market for fuelwood has been developing. Small, poor-quality timber can now be sold for firewood in many areas. Silvicultural practices that once involved out-of-pocket expenses can now be done at a small profit in those areas. The up-front cash flow means that owners no longer need to carry an investment for a long period when they initiate the management of their woodlands.

The fuelwood market is important to all woodland owners. For public owners it means that they can provide additional benefits and at the same time, lower the overall cost of providing a mix of benefits. For industrial owners it means cost efficiencies. For nonindustrial owners, including farm-woodlot owners, it may hold the key to initiating timber management.

Most farmers are able to stockpile and sell firewood during their normal off-season. Many are able to administer sales to do-it-yourself cutters, regardless of season. In addition the occasional, part-time cutting of firewood would provide a reasonable challenge to many of the families who have returned to the earth in recent years to test their self-sufficiency.

Forestry Assistance

We noted earlier that relatively few private owners have sought forestry advice or taken advantage of the assistance available to them. And that few owners apparently know where to seek help. Although these statements are true, the relativity masks the absolute numbers and it may not apply to farm-woodlot owners.

Most foresters who assist landowners have both productive records and lengthy backlogs. But they are few in number compared to, perhaps, three million private owners. In 1979 more than 180,000 woodland owners received assistance under the Cooperative Forest Management Act and related legislation. More than five million acres were involved (7). Many more were helped by private consultants and industry foresters.

Most farm woodlot owners are likely to be familiar with extension and conservation services that are available to them. Many may have used those services, but their numbers may be hidden in the statistics for all private owners. If not, we can readily promote and disseminate forestry advice through those familiar services.

Nontimber Outputs

As noted earlier, most public owners have a stewardship role and are charged with multiple-use objectives. Their managerial efforts are aimed at producing both timber outputs and nontimber outputs--water, forage, wildlife, and recreation. The cost of producing them is borne largely by the general public. Direct charges to actual users are generally minimal.

Industrial owners also produce nontimber outputs. But they usually absorb most of the production costs as part of their social responsibility. Like public owners their charges to users are also generally minimal.

Most nonindustrial private owners, too, seem to have multiple objectives for their woodlands, which may or may not include timber growing. But their roles are more as consumers than as producers of nontimber outputs. Most of them seem to measure their success in satisfaction, rather than in dollars.

Outdoor Recreation

It is likely that many nonfarm, nonindustrial private owners hold their woodlands primarily for outdoor recreation--for hunting and fishing, for outings, for birdwatching, for simply viewing and contemplating the joy of ownership. Many of their woodlots serve as sites for vacation homes. Most farmers, on the other hand, are likely to consider outdoor recreation as a secondary reason for holding their woodlands. Both groups, though, share many of the same experiences as consumers of recreation benefits.

Few nonindustrial private owners seek income from recreation on their forest lands. Most keep them for their own use. In most areas their competitors in the recreation market--public and industrial owners--provide good facilities at subsidized rates. However, by minimizing the use of their lands by outsiders, nonindustrial private owners also minimize their liability risks.

All forest owners, public and private, must bear the cost of controlling litter and vandalism. Most public and industrial owners have paid employees who handle those onerous jobs. Nonindustrial private owners do not. While they may face fewer such problems, the time and out-of-pocket expense to correct them can be extremely burdensome. Nonfarm private woodland owners, because they are usually away from their properties for long periods, are especially troubled by unwanted guests.

Water

Although forests provide their owners with benefits such as spring water and erosion control, most of the watershed benefits they provide are enjoyed by other people downstream. So, in a sense, all forest owners are producers of watershed benefits, even small-farm forest owners. But, with few extreme exceptions, none of them sell water.

Our society expects forest owners to protect the quality of the water in our streams and lakes. More and more in recent years, our society has backed up that expectation with environmental regulations. While those regulations apply generally to all forest owners, they are likely to cause more concern among nonindustrial owners than among public and industrial owners.

Public and industrial ownerships are usually under someone's watchful eye. Part of their managerial requirements are to keep up with changes in environmental constraints and to examine alternatives for complying with those constraints. Most such ownerships have staffs for doing that. Nonindustrial private owners do not. Yet they are expected to comply with the same constraints in the use and management of their forests. A logical response in this situation is to do nothing. It is likely, too, that many nonindustrial private owners refrain from cutting their woodlots because they are unsure of the environmental effect.

Wildlife

Forests provide food, cover, and homes for wildlife. Forest owners, then--without even trying--are producers of wildlife benefits. But, unlike water, forest owners can manipulate forest cover to encourage desired species to either move in or stay there.

Public and industrial owners are more likely than nonindustrial owners to incur the costs of wildlife management--exceptions, of course, would include hunting and fishing clubs. Yet, in all the states that I know of, game belongs to the state. While a few owners may charge for the privilege of hunting on their land, none can charge for the game itself.

Nonindustrial private owners and their friends tend to consume, themselves, their home-grown wildlife benefits. Some enjoy hunting and fishing. Some enjoy observing wildlife. Some simply like the confidence of knowing that the wildlife is there.

Appreciation in Value

One last nontimber output from forest land is linked directly to the timber itself: the increase in timber's value as it grows. With rare exceptions forest stands continually increase in value through most of their lives. The exceptions include such catastrophes as storms and infestations.

Hardwood stands in the northeast generally display average annual volume growth of three or four percent. If stumpage prices held steady, that would mean an annual value increase of three or four percent, just from the physical growth. But stumpage prices do not hold steady. Historical trends indicate that changes in hardwood stumpage rates run, generally, a little higher than current inflation rates--as much as two percent higher for sawlog stumpage and as much as five percent for veneer stumpage. Actual stumpage prices and the rates at which they change will, of course, vary among local areas and over time. But the important thing is that hardwood stumpage prices usually have a premium over inflation rates.

Land values have similar premiums over inflation rates. Past experience in many areas indicates that the premium runs generally two or three percent.

It appears, then, that the general appreciation of timberland values holds some investment potential. For many owners it does. But to capture those timber values, the owner needs time, money, and technical expertise. Many public owners and most industrial owners have those resources. Few nonindustrial owners have all three. Not many, though, seem to mind all that much: they have their forests, instead.

SUMMARY

Small-farm woodlands are an important segment of our nation's commercial forest land. Found mostly in the east, they amount to more than 13 million acres. Although most farm woodlot sites are not the best farming sites, many are good for growing timber.

Small-farm woodlot owners are an important segment of our nation's nonindustrial private forest owners. We do not know much about either. Until we direct studies at small-farm woodlot owners (and other major segments of nonindustrial owners) we will need to rely on existing studies. The major conclusion that we can draw from them is that there is no "typical" forest owner.

Most farmers probably own their forest land because it came with the farm. While many hold their woodlands for their own use, few seem interested in growing timber. Most, instead, seem more interested in nontimber outputs. Most have a consumer orientation to both the timber output and the nontimber outputs of their woodlands.

In facing problems that are of general concern to all forest owners, farm-woodland owners are usually at some disadvantage to public and industrial owners, yet usually hold an advantage over other nonindustrial private owners.

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LONG-RANGE RESEARCH PLANS AND ACTIVITIES OF ARS TO SUPPORT THE NATIONAL RESURGENCE OF SMALL FAMILY FARMS

Howard J. Brooks [1]

ABSTRACT

The Agricultural Research Service (ARS) has a segment of research targeted to the needs of the small farmer but the improved technology that results from all ARS programs can be used to serve the small farmer. The ARS small farms research programs are located primarily at three centers - Booneville, Arkansas; Charleston, South Caroline; and Beltsville, Maryland. Research conducted at these centers relates to regional and national needs. Cooperative research programs have been established with State agricultural experiment stations to help solve more local problems. To the extent that resources permit, ARS long-range plans include continued operation of small farm research centers, continued emphasis on horticultural and forage-livestock programs, increased emphasis on marketing research, continued use of State-Federal regional research committees, continued allocation of extramural research funds to cooperative State programs, continued use of surveys of small farm research needs, closer working relationship with extension agencies, and continued support of the Department's initiative to help the small family farm in America.

Keywords: Small farms, research, ARS.

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The Agricultural Research Service has always recognized the need to serve the small family farm. Not just because it is a small family farm but because small family farms are an important part of American agriculture and our research is intended to serve all of agriculture. There is a segment of our research that now is targeted to the needs of the small farmer but the improved technology that results from all of our ARS programs can be used to serve the small farmer.

Over the years, it has been the availability of agricultural technology and farm economics that has forced the increase in size of the average American farm. One hundred years ago, the majority of farm produce was from relatively small farms with most of the labor provided by family members. Today, the major share of farm produce is from relatively large farms with most farm operations fully mechanized. Our U.S. agricultural scientists provided the technology to increase agricultural productivity, the State and Federal extension services provided the education programs for technology transfer, and farmers provided the local skills to put the technology into practice. All America has benefitted. Our high standard of living would not have been possible without a strong agriculture and an abundance of food.

In a way, the small family farm of yesterday has become the unintentional victim of mechanization and advanced agricultural technology. On the average, the small family farms of this country provide less farm produce on a per acre basis than do the large farms and according to Dr. Tweeten, they do it at a greater capital cost per unit of output. Many small farms simply do not have the acreage necessary to be economically viable units. True, the same technology exists to the small farmer that allowed the large farm operator to become even larger. But without the necessary acreage and access to capital, many small farmers have been unable to compete with large acreage farmers. As a consequence, many millions of acres of farmland are relatively unproductive as the land owner and his family have turned from farming to off-farm employment for all or part of their income.

The demise of the small farm in America is shared by the corner drug store, the small country store, the butcher shop, and the harness shop. All have largely disappeared. So has the local telephone office with its bank of telephone operators. So have the ice man, the meat man, the fish man, the Grand Union tea man, and the junk man that went from house to house. Many of us remember those days--the good old days as some might call them. The point I am making is that all America has changed--not just agriculture.

Congress has now directed that the Agricultural Research Service initiate research programs to meet the needs of the small farm operator. The level of funding in fiscal year 1981 is $4,000,000. Dr. King has told you how we have responded and what some of these research programs are. They are modest programs, to be sure, but along with our existing programs, and in cooperation with State agricultural experiment stations, the 1890 colleges, and the Federal and State extension services, we are confident that we can do much to help the small farmer.

It is not our mission in ARS to conduct research to solve local and State problems--that is the mission of individual State agricultural experiment stations. It is appropriate that we identify problems facing U.S. agriculture and conduct research that complements the total small farms effort. It is the larger issues of national problems that we will try to address with small farm funds. As with our other programs, whatever we do must be in concert with our State colleagues. True, we are now under serious fiscal constraints but we are fully supportive of the President's economic recovery plan. Nevertheless, to the extent possible, we plan to implement the following programs which are designed to better serve the small farm sector of this country.

We intend to continue to maintain active programs at our existing small farm research centers at Booneville, Arkansas; Charleston, South Carolina; and Beltsville, Maryland. Research at other ARS locations directly supports the programs being conducted at these centers. Also, research by ARS scientists not now directly associated with small farms programs will be evaluated to see how it might support small farms research at these centers. We will focus on developing integrated small farm enterprises. The ARS Small Farms Committee will continue to coordinate these activities, to develop long-range plans, and to recommend how our limited funds can best be used to serve national needs.

We plan to continue to emphasize horticultural crops and forage-livestock programs in the ARS small farms research programs. It is these areas that appear to have the most potential for improving the economics of farming small acreages. To the extent that resources permit, small animal and other appropriate areas of research will also be considered.

Increased emphasis will be given to marketing agricultural produce from small farms. There are many small family farms that operate close to metropolitan areas. We believe the opportunity exists to help these farmers develop better markets for their produce, many of which are specialty items. There already has been a marked increase in the use of roadside markets and pick-your-own operations. We encourage continued development of such marketing systems. There is an even greater need to help those small farm operators who live in more remote areas.

Through the participation of State-Federal regional committees, we plan to continue to develop cooperative small farms research programs with appropriate State agricultural experiment stations and 1890 colleges. The Northeastern Region already has regional committees in place for horticultural crops and forage-livestock research programs. Development of such committees in other regions will help to identify research of greatest national need and help maintain a close working relationship between State and Federal scientists.

Surveys of the research needs of small farmers in various parts of the country will be continued and research programs will be adjusted accordingly. Two such surveys have already been conducted in the Northeastern Region and Mr. Howard Kerr has presented at this symposium the findings of his most recent survey.

To the extent that extramural funds are available, we plan to continue to use them to support small farms research projects with cooperating 1862 and 1890 institutions. Since many of the existing small farm problems relate to local problems, it seems appropriate that the State institutions conduct much of the applied research. It is likely that any new initiatives to support small farm operations will come from individual States rather than from a congressional directive to the USDA Agricultural Research Service.

We will encourage the Federal and State extension services to continue and expand their interest in the research conducted at our ARS small farms research centers. With advanced planning and cooperation, we could design research-demonstration projects in such a way that researchers and extension specialists could use the same facilities for both the development and demonstration of new technologies for the small farmer. The suggestion has been made that extension specialists might be located at one or more of our small farms research centers and we support this suggestion.

Finally, we will support the efforts of any USDA or other government agency that sponsors or wishes to promote small farms programs. Through our collective efforts, I hope we together can provide better support to the resurgence of small farms of this country. We in ARS are fully supportive of the Department's initiative to help the small family farm in America.

SESSION VI

PANEL DISCUSSION

Highlights and Key Issues of the Symposium

Co-Moderated by
Lloyd Knutson, Chairman, Insect Identification and Beneficial
Insect Introduction Institute
and
Essex E. Finney, Jr., Assistant Director
Beltsville Agricultural Research Center

Introduction by

Harry Herlich, Chairman
Animal Parasitology Institute

Dr. Miklos Faust is a member of the staff at Beltsville. He received a B.S. degree in horticulture at the University of Budapest and graduate degrees at Rutgers University and Cornell University. He has been a farm manager in Hungary, research assistant at Rutgers, Cornell and the New York State Agricultural Experiment Station, research associate with the United Fruit Company, plant physiologist at Beltsville, and he is currently Chief of the Fruit Laboratory, Horticultural Science Institute.

Mr. Leslie N. Firth received a B.S. degree in animal science and a M.S. degree in farm management at Pennsylvania State University. He has been a Cooperative Extension worker for 24 years. His expertise is in farm management programs and he works with approximately 1200 small farms in Mercer County, Pennsylvania. He is the immediate past president of the National Association of National County Agricultural Agents.

Mr. Howard W. Kerr, Jr. is a native of Maryland and was reared in a rural environment. He received B.S. and M.S. degrees in agricultural economics at the University of Maryland. In 1960 he joined the Economic Research Service, USDA and in 1968 he joined the Agricultural Research Service. In 1979 he was named Coordinator for Small Farms Research in the Northeastern Region. He is also a part-time farmer, having operated a successful pick-your-own fruit and berry farm in the Baltimore suburbs since 1970.

Mr. Rod Parker was raised on a small tobacco and cattle farm near Piscataway, Maryland, where he attended elementary and high school. After graduation from Georgia Tech University he joined the Navy and became a pilot. After two tours in Viet Nam he returned to the family farm in 1974. Today that farm is still primarily a tobacco and cattle farm but now it is diversified, and horticultural crops are emphasized. Several acres of vegetables and berries are produced for direct marketing for pick-your-own, roadside stands, retailing to farmers' markets, and wholesale to farm stores and commissioned merchants.

Dr. Richard L. Ridgway received his undergraduate training in agronomy at Texas Tech University and graduate training in entomology at Cornell University. He was employed by the Texas Agricultural Extension Service and later was a research scientist with the Agricultural Research Service at College Station, Texas. Since 1975 Dr. Ridgway has served on the National Program Staff, ARS, at Beltsville, Maryland. For many years he has had a special interest in biological control of insects and its relationship to organic farming. In 1979 Dr. Ridgway served on a special task force within ARS to review the agency's small farms research program and to provide recommendations on the development of the Southern Region's Small Farms Research Center, Booneville, Arkansas.

Dr. Dale W. Zinn is Dean of the College of Agriculture and Forestry and Director of the West Virginia Agricultural and Forestry Experiment Station at West Virginia University. He received his B.S. and M.S. degrees in agriculture from West Virginia University and his Ph.D. in animal science from the University of Missouri. Dr. Zinn has held various positions in research, teaching, and administration at the University of Missouri, New Mexico State University, Texas Tech University, and West Virginia University. His enthusiastic promotion of agriculture and forestry is evidenced by the state, regional, and national leadership he has provided as a member of the West Virginia Farm Management Commission, the West Virginia Soil Conservation Committee, and Mountaineer's for Rural Progress.

These are the panelists, and I will now turn the discussion over to Dr. Finney and Dr. Knutson.

Panel Discussion

Dr. Knutson - We are sorry that Dr. Steven C. King, the Deputy Administrator for Agricultural Research, Northeastern Region cannot be with us this morning, but Dr. Finney and I will try to do the best we can to ferret out some interesting, insightful responses to the three questions that Dr. King sent to our panelists before the Symposium. We are going to combine two of Dr. King's questions, taking about 25 minutes to go around the table, responding to these. There will be a third question, and we'll have 10 minutes at the end of this discussion for questions from the audience.

The first is a combined question. That is, what are the key accomplishments of small farms research that have been brought out in this Symposium, and what are the most significant small farms research needs? Also, we would like the panelists to bring out any gaps in this Symposium's coverage. We would like the panelists to speak from their perspectives as a farmer, county agent, director of an experiment station, scientist, and research coordinator. I would like to ask Dr. Ridgway if he would respond to the first question.

Dr. Ridgway - Perhaps I will start by making just a general observation on the accomplishments from the perspective of a person that has had a keen interest in the small farms research program and who has been somewhat peripherally involved. The first thing that comes through to me very clearly is that we have made substantial progress in a relatively short period of time. When I look back to when we were first struggling with how to put together a small farms research program and then observe what has happened the last three days it is obvious we have made a lot of progress. Perhaps even more important, this week a lot of people have been brought together that we need to be talking with. I think I'll forego any comments on specific examples of research progress and move on to comment on research needs. I identified 5 or 6 areas where additional research is needed as I listened to the various presentations. These needs include equipment, fertility in intensive multi-year cropping systems, conservation tillage, energy, and economics. But I think I would like to comment on the equipment issue in particular. You heard some discussion of this issue earlier today, so some of this might be repetitious, but I would like to share with you my perspective. Going back to Howard Kerr's survey in 1979, 22% of the people that responded said there were equipment research needs; and as you heard earlier this morning, that figure is higher in the latest survey. When we look at Steve King's report of how the 3.8 million dollars for small farm research in ARS is allocated, about 1% of those resources can be easily identified as being allocated to equipment research. From my perspective there is a discrepancy somewhat between the perceived need and the actual program. I think one of the reasons that the research effort on equipment isn't larger is that the research planners and performers have some difficulty in identifying the researchable problems. And I think that this symposium will help a good deal in that regard. I would share with you that the need for communication in this area was identified early in the week and we had an informal mini-symposium at lunch yesterday, in which we had equipment manufacturers, agricultural engineers from both the state and federal system, farmers, and agricultural administrators represented. Communications have been initiated much as a result of this symposium, for the professional people to begin to look carefully at how we might address the equipment research needs. I personally believe that there is a role here for the public sector to synergize the equipment research and development system and I certainly hope that's one of the things that will come out of the symposium.

Dr. Zinn - All the questions raised by Dr. King seemed to ask for specifics. I think there's also a matter of our attitude and philosophy toward small farms for which I hope we come out of this symposium with a little better understanding. I'm looking at the symposium from a research viewpoint, which is basically what the symposium is about, and I see in the 3 days of the programming some mixed signals as to who we are, what we are, and who our constituents are. I think each of us must have our own idea as to what constitutes a small farm, or small farm family. The idea of a small farm family gets confused when we start talking about mom, dad, and one child. For some, this is a small farm family; however, for others, the picture is different. In their mind it is mom, dad, and six children. We really don't understand because there is no clear definition of a small farm family; therefore, we need to be a little bit more concerned about the terminology that we're using. It probably is time that we pause and assess ourselves as to who are our clients. From a research viewpoint, who are they, what are their needs now, and what will their needs be? I think this is very important when we start talking about small farms research. In this conference, throughout the 2-1/2 days, we have seen emphasis on research that is needed to assist the part-time farmer in making more effective and efficient use of his input resources into his agricultural farming operations. On the other extreme, we have seen emphasis on research towards more intensive agricultural production practices on limited acreage, the practice of which requires intensive capitalization, high technology and management, and in effect full-time farming. There were two papers presented during the first morning that give us at least a clue as to who our clients are and will be. If we look at Dr. Tweeten's paper, which indicates that we are seeing a rapid increase in the number of part-time farmers and in broad research program areas, and the emphasis in the paper by Mr. Kerr in the Northeast on forage livestock and horticulture as being the two major agricultural enterprises that have the biggest impact region-wide, this gives us at least a bit of a clue. I believe we are confusing the distinction between our traditional understanding of the family farm and the small farm. We are continually confusing these two issues. I am convinced that the socio-economic structure that continues to exist will make the traditional family farm the flagship of American agriculture. I would submit that the small farm we should be focusing on can best be defined as part-time farming for profit, which is acreage size and gross income neutral. We as researchers should not have illusions that our research program should be designed to move the part-time farmer into a full-time category. Certainly some will, but the majority of part-time farmers choose to be part-time farmers and will continues to be part-time farmers, and this is what we should be focusing on. The illusion that we are going to move all part-time farmers into full-time will not happen, nor should we be naive enough to think that agricultural research in and by itself will change the structure of agriculture in this country, because it won't. As pointed out by Dr. Madden in his presentation this morning, research increases our understanding of biological truths and the interactions thereof. As Director of a State Agricultural Experiment Station, which is an integral part of our national agricultural research organization, I am disgusted with the daily implications that the programs of our national research organization favor one group of farmers over the other. If one looks at research from the standpoint that research is the exposure of biological truths, and that as such is size-neutral, then the accusation holds no water. It is the integration of the scientific discoveries into technological improvements and a transfer of this technology through the production agriculture and socio-economic systems programs of extension and education that removes the size-neutrality from research. For agricultural research to be of value to the part-time farming-for-profit family, we must develop the educational and extension delivery system that will enable all production agriculture to take advantage of the discoveries of agricultural research.

Mr. Parker - I'd like to direct my comments to two different groups; one to the researchers here, and one to the farmers. One of the things that we as farmers appreciate about the Department of Agriculture in general is that their dollars are spent to help people help themselves. And I would like to charge you researchers to keep that in mind all the time, whatever the program is that you are looking at. Sometimes, I feel that there's an awful lot of political empire building. I as a farmer, feel that a lot of the things that were getting shot out at me today didn't really mean a whole lot. I appreciate the fact that you need statistics to know where you're starting from and where you're ending up, but, to be quite honest with you, I don't need statistics. I'd like to challenge you that as you do your projects you consider the bottom line from a farmer's viewpoint, "Is it going to make any money, or does it have the potential to make some money?" And I would challenge you to ask yourself that question every day as you directors assign projects and as you researchers work on them. If it isn't going to do that, then I would say, "If you're going to spend my money, forget it." Take a look at the bottom line of the programs.

I was gratified by some of the challenges that were thrown out to the researchers. As farmers at this symposium where we have 50% researchers, I have to confess that we are in some ways so uninformed that we don't know the questions to ask. We don't really know what to tell you to do for us. I think if you came to the farm and we were sitting there talking, that perhaps we'd be a little bit more on common ground. But, I find myself at a little bit of a loss as to what to suggest to you. One of the critical issues (and this is what this symposium is about) is communications. We need to communicate. Unfortunately, I'm afraid, I didn't feel that this symposium was a good avenue for that. Where I do see some communications taking place is in the Extension Service, and I know that USDA has two or three hats that they have to answer to. As someone here mentioned, they're kind of the orphan child. Nevertheless, I would really like to see some research done on how to train county agents to be effective communicators. And I would just like to take one second and give an example. We have a county agent here in Prince Georges County, who came to the county straight out of the University of Maryland. He came from a dairy farm in Montgomery County, and went down to Prince Georges where there's not a dairy farm in the county that I know of. He didn't know anything. And, the best thing about him was that he was able to have the farmers discern that and not loose his composure. He came down and he stuck with it. And the best thing was, if anybody asked him a question, he'd look for the answer. He's been down to my farm at 8:00 P.M. to deliver some pamphlet that I've asked for. I tell you that's dedication and I don't know that we're going to get that in everybody, but that's the kind of attitude that we need. He's been there about 6 or 7 years now, and now he knows what tobacco is, and he knows how to handle it, and he knows a little bit about horticultural crops; he's a good county agent because he's a communicator. He drops in at least 10 times a year to talk about what's going on, and find out what we need. I don't know if that's unsual or not, but it's the kind of thing we need to improve the communication that we are looking for.

There are 3 areas that I think we need to look at. One speaker addressed financing briefly. I think the biggest area that farmers are unaware of, and Luther Tweeten brought this out, is that they don't know how to use the leverage that is available to us, financially. I don't know how much research that you people can do on that, but there is a lot that can be done to help the small farmer in his financial plight. The second thing is production, and this was not a production meeting. I don't know if some of you farmers were expecting that. The third thing is marketing, which we've just addressed, briefly. It's like a three-legged stool in farming, You take one of those legs away and the stool is going to fall over. We need to be educated, as one of my colleagues up here said, on all 3 of those aspects.

Now I just want to express the views of farmers a little bit more and also address the farmers. I don't know what you came expecting to hear in this symposium, but as I drifted around during the coffee breaks I detected some dissatisfaction. I think some of you were bored by a lot of the statistics. I was too. And so I would respectfully recommend that perhaps we can maybe avoid that, unless that is what this meeting is about. I felt sometimes that when I was looking at the projection screen there was a double-barrel shotgun sticking out and they just let fire with both barrels, we got blasted away by a lot of details that we couldn't digest, and I'm not too sure how valuable they would have been to me if I could have digested them. I would suggest to you farmers that there are a lot of other meetings that deal with marketing specifically, 3 or 4-day meetings. There are some other meetings that deal with production. And your extension agents and the people here know about them. Find out about them because I think that a lot of the things that you missed or perhaps were looking for here, you will get at these other meetings. I'm sure you are all aware that your extension agents have reams of pamphlets that address the problems that maybe you were looking for answers to at this meeting. I think that one of the things that excited me when I came here is to see how many people were here. I had no idea there was going to be this many. And from that aspect I think the meeting is a resounding success.

Now let me tell you one other thing that I think you should get out of this meeting and I wish I could have said this at the beginning of the meeting. Allen Stoner was talking about plastic mulches, and I was real interested so I said to him I want you to answer a question for me. He said well, "I'm not sure I've got the answer here for you. But I'll give you the telephone number of a person who is the best specialist in the country." And he did. If I was asleep all the rest of the symposium, that one contact made it worthwhile for me to come here. And I think you farmers need to realize that contacts, not only with the research people but with other farmers who are doing the same thing you are doing, are probably the single most important thing that you will get out of a meeting like this. It's a little bit late for you to make contacts but it's not too late.

Mr. Firth - As a county agent and a part-time farmer, I think I would like to follow up on what has been discussed to some degree this morning. I think the accomplishment that is apparent to me today is that there is a lot of information and a lot of knowledge already available to assist farmers, particularly small farmers. The significant thing to me is the apparent need to focus on innovative ways to deliver this information. Let me give you a couple of examples. If your county extension program is not what you think it should be, there is a local extension board of directors who can make it happen. There needs to be a outstanding library in every county extension office. State extension services and local extension boards of directors need to utilize the computer capabilities that we have in this country so we can pull information out of Beltsville, out of the National Agricultural Library, out of the state experiment stations, etc., to address your problems. And you out there in those counties can have some input to that. Now what do I think are the most significant small farms research needs? It was apparent to me that we did not see a lot of economics on any issue that was developed this week. I work with farmers of all kinds; the bottom line is, "Will the enterprise make some money?" I have to have the information to develop a budget for them. We get worried about cash flow and related problems. I would like to see the county agent in this country and you, the farmer, have the price projections that are available! Now, that's asking for a lot, but your counterparts, the big farmers, have access to information at their fingertips. We have to make that kind of information available to everybody. We need to work at developing markets. We need information on markets that are available. Time is dear for a part-time farmer. I think we need some research on how to use our time more effectively and to assess the problems and situations that will make us the most money. We need some research on how to get hold of some of this larger, more efficient equipment. Barter, work with your neighbor, maybe joint-ownership or custom-hire; which is the best way to go to make ourselves more efficient? As far as production-type research--to me one of the most significant areas that we need to be working on is in the area of harvest and storage losses. It really hurts to produce a crop and lose 10, 15, 25 percent of it before we get it in storage. As a county agent, one of the things that would help me as I work with small farmers would be to have a smorgasbord of concepts that I could lay out to them on various crops or livestock potentials, with a bottom line of how much money it will make, and then the necessary answers to the ultimate question of "where am I going to sell the product?"

Dr. Faust - Well, I'm looking at this strictly from my narrow point of view was a fruit researcher and scientist. While writing my paper for this meeting, I was surprised at how little research is being conducted that is applicable to the small or family farmers. Fruit farmers, working on small acreage, are usually farmers who grow several types of fruit in the same orchard. Very little research in this country is applicable to this. Most of the examples that I use today come from Italy, Hungary, Poland, Germany, and other places from all over the world except here. So in this respect, I think we could do a lot more. Now, what are the things we should do? Fruit farmers are located near the city. They need an orchard system so they can supply fruit to the local clientele during the entire summer. They need tree forms that are compatible because they cannot buy special machinery for cherries and special machinery for blueberries - it has to be one system that will work for all. This is the number one need. Whether they are all dwarf tree types or all flattened-out tree types doesn't really matter, as long as they are uniform. The other need is for specialized machinery. I am really surprised at engineers who think the small farm needs scaled-down large machines. This is not my idea. The small farmers need special machines, sometimes hand-assisted, sometimes picking platforms, sometimes the same platforms that can be used for pruning, picking and thinning. In Italy, some of the machines are used as much as 180 days in the same 18 or 20 acres because they do a lot of different operations well. This is the type of machines that we need. We need special spray machinery. We have the ideas and the prototypes of ultra-low volume sprayers but they do not work well on windy days. The small farmer can spray on days when the wind is light, so the small particles are not blown away, and the spray is deposited on the trees; however, the larger farmers cannot choose the spraying days, so the concept is not being developed. Yet we could use one-gallon spray material per acre, which would be useful in decreasing spray pollution on fields located near cities. We need very special machines; for example, we need one that can renovate a strawberry bed so that the strawberry plantation can go for 4 or 5 years instead of one year; thus, the cost of replanting every year is saved. We need to adapt the plants to grow in conditions that normally are not the most productive. In the last 30 years, we have selected the most productive plants in this country and planted them in areas where they are well-adaptable, and from there we transported the fruit to market. It doesn't really matter whether the pears come from Oregon, the apples from Washington State, or the grapes from Southern California. We bring them here. The small farmer has to grow these crops here. Therefore, we need plant material that is adaptable to local conditions, will do well and will be very productive.

Mr. Kerr - Some very interesting points have surfaced and I would like to add just a few additional comments. Contrary to the concept of economies of scale that have been preached many years by economists, I suggest for the small or part-time farmer we should teach economies of time. Time, not size, is the most important factor for small and/or part-time farmers. Also, I recognize and support the need for small-scale equipment. In my publication included in your folder of symposium information, on Table 8, equipment is identified as the most important need of small farms in 1984. I might add that the NER small farm extramural horticultural master project in FY 1983 will focus on equipment needs for horticultural production.

In response to Dr. King's question, the Symposium's real achievements will surface only in the future and will be measured by what will be done to implement the furthering of America's small-scale agriculture.

This Symposium is perhaps one great catalytic agent providing a voice for individual small farmers to express their various needs and is a sounding board, communicating the transition that is occuring in our agricultural industry to all who will listen. We have successfully brought together "seekers and providers," meaning those individuals with needs and questions to be answered and those scientists and technologists who are attempting to answer the questions and fulfill the needs.

Among the most significant small farms research needs, identified through a consensus of the papers presented here and from in-depth discussions with involved people, are improvements in marketing and management systems, development of appropriate small-scale agriculture equipment, and improvement of the methods to allow more intensive farming systems than those currently used. With limited funds available and little hope of increased funding levels in the near future, it becomes a great challenge to allocate the limited funds that are available to areas where they may be used more effectively. This audience represents a wide sampling of our domestic agriculture, and the interests of practically all states are represented. This is new testimony reflecting the need for a small farms research program that is universally strong throughout. At present, the program focuses on the Northeastern Region and the Southern Region; unquestionably, many of you in the audience from the North Central, and Western Regions would likewise like to have and should have a viable program to assist and fulfill your particular small farm research needs.

Dr. Finney - Thank you Mr. Kerr. There is an additional question Dr. King wanted to raise to the panel. Then we will go around the audience for a question and answer session.

In a number of instances, I believe some of the panel members have already touched on this issue, but to insure that they have the opportunity of clarifying their concerns, the question that I would like to ask is: "What should be the options selected for emphasis during the next few years in research to accommodate the needs of small farmers?" That is, we have heard a number of things in terms of problems, issues of concern, but what would be your view in terms of the most important issue that should be emphasized during the next 2 or 3 years?

Dr. Ridgway - I think in responding briefly to this one I might just pick up one other area that I mentioned earlier. If my memory is correct, and I think I heard most of the papers if not all of them, there was very little discussion, particularly by our university and federal researchers, about cultural systems, soil fertility, and soil management, where we had multiple crops over several years. We heard descriptions of this type of agriculture from Sam Smith, Dick Harwood, and Dr. Whatley. Research in this area is extremely important. The limited amount of systems research currently being conducted probably contributes to the difficulty of identifying researchable problems on equipment because we are uncertain about the kinds of production systems for which we need equipment. I would hope, that as we look forward to the next year or two, that we will see a good deal more formal research that's looking at these modified, multiple-cropping systems. Whether Sam Smith's 7-year rotation in permanent beds is the answer, is the kind of thing to be examined. It will have some kind of application someplace, and modifications of it probably will fit other places. But I do feel there is a real void in our formal research in this particular area.

Dr. Zinn - In focusing on specifics within the two broad research categories that at least are important at least in the Northeast, it seems to me that we have two areas that we really ought to focus on. One of these is market alternatives. It does us very little good to increase productivity if we don't have adequate markets to assure reasonable prices, and I think we've got to spend considerably more effort than we do now on market alternatives within various parts of the Northeastern Region. The second one, and it's one that is very important, I think, to the part-time farmer, is equipment. Equipment that not only is sized to his operation but is cost effective. It's going to be extremely difficult to go out and pay $10,000 for a tractor to produce a $2,000 crop. And I think we've got to emphasize this to a great extent. The other thing is the point that Dr. Ridgway just focused on. I think we still need a great deal of basic research in soil structure, soil fertility, and soil physiology. We don't know much about it yet in terms of intensity of types of agricultural practices. These are three areas that I think we've really got to focus on.

Mr. Parker - I think I would agree with you Dale, that the biggest way we can help the small farmer is marketing alternatives, and then the second is financing.

Mr. Firth - I just have one thought to add to what has been said, and that would be to work on projects that can make the most productive use of the precious time of part-time farmers.

Dr. Faust - I think the difference between a small farmer who lives well and a small farmer who is poor is the ability to know what to do. In orchards, with all due respect to the county agent, I don't think they know how to put more fruit on the same tree. What are the small details involved in how the production can be increased? So my first priority would be some sort of computer-assisted visual educational system. The other is new orchard systems and machinery that tie the systems together to help farmers operating on a small scale.

Mr. Kerr - As NER Small Farms Research coordinator, I see the key issue as a need for teamwork and cooperation among scientists, extension personnel, the farming community, business, and industry. It must prevail. We heard that echoed by Secretary Block, who visited this facility last week, and some of us heard it again last night from Mr. Norris, our banquet speaker, explaining how his corporation and many other major corporations are involving themselves in the development of new concepts for small scale agriculture. All available options must be analyzed -- such as equipment, marketing, economics, education, financial issues, and the government's general food policy — and the best method identified to pin-point research objectives of the future.

Dr. Finney - Thank you very much, panel. I believe we have reached the time where we will have a chance for the audience to participate, either in terms of a comment or in terms of raising a question that they may wish to have the panel members address.

Audience - As a couple of the panel members know, I have traipsed around the Beltway over the last year trying to interest some of the computer and information managers to move more into some commercial prospects for information dissemination in agriculture. More recently I have found out that William Norris more than stole my thunder. He has the thunder, I had sort of a little squeal on this subject. One of the points that he raised in his banquet address was that agricultural information centers could be commercial operations. I'd like the panel, and especially Rod Parker, to address this question. What are the prospects? Where would such a system fit in with the Extension Service? Where would it be competitive and where would it be complementary?

Mr. Parker - This seems like an ambitious undertaking, to be honest with you. I'd like to amend one thing that I said and that is I agree with what Dr. Faust said about the difference between a prosperous small farmer and poor one is the knowledge that he has. That is exactly the truth. And I think that knowledge, in whatever way it can be obtained, is the thing that all farmers have to have. I think that computers would have a terrific impact on the educational system. The problem is, especially with small farmers in the older age category, or perhaps those that have been in it for a long time is getting them to use it. So I think the Extension Service would have to be involved. Perhaps such offices could be set up somehow in conjunction with the Extension Service. I realize there would be a lot of problems there. But even if the extension agent knew about the use of computers I think it would fit in because education is the key to lifting the small farmer out of his problems.

Audience - How much would you pay for this computer service?

Mr. Parker - I don't know. I guess I would have to take a look at what are the services offered. I'm sticking my neck out, but I'm willing to do that once in a while, and I think maybe a couple of thousand dollars a year, if it were really worthwhile.

Audience - As a publishing company, we make our living by the written word at the moment, and we're looking another 10 or 15, 20 years down the road to where the written word on paper will not be used anymore. In other words, we are looking to electronic publishing. I'm wondering, as a general question to the panel and especially those in the Extension Service, if it wouldn't be well to look a few years down the road to set up your service and your information dissemination much the way Control Data Corporation is planning. We're looking to do this as a publishing company. In the future, and the very near future, a significant portion of the American homes are going to have computer terminals for information dissemination.

Mr. Parker - I guess you are saying what I said. I think we need this and should have had it a long time ago.

Dr. Faust - Yes, I'd like to respond to this. With these cassette type of video tapes coming out, I see a tremendous need for a visual, through-the-home television system, something on how to prune a tree for example. I think everybody who has even a few trees at home could use this system. But it has to be visual and has to be fairly clear and well done.

Audience - As a small farmer it's very difficult to get to seminars or symposia like this. Why couldn't the extension offices have programs developed where they could go, for example, to Whatley's farm or the Caretaker Farm, and show the farmers in our areas what other successful small farms are doing and develop models for them? Why can't we look at really successful farms all over and bring those to the people through the Extension Service? Would the extension representative like to respond?

Mr. Firth - I'm not sure that I fully understand the question. Are you referring to having tours or seminars on location?

Audience - No, but slide programs made available to the extension offices so that they could then use these to motivate the people to be a little more creative in thinking about their own small farms.

Mr. Firth - I see absolutely nothing wrong with that. I am sure it is being done to some degree in a variety of cases right now. I would suggest you sit down with the extension agent in your county and talk with him about your needs.

Audience - I have a comment and a question. The comment has to do with the discussion we've had about computers. I had the privilege of working on a computer-based information delivery system for the extension service in Michigan and I want to remind people that a computer is more than a book that happens to be flashed on a TV screen. If we only use it for that we are trying to hit a thumbtack with a sledgehammer. A computer is a data-management tool and a good deal of what farmers do has to do with managing information in real time. But they have to be able to keep track of a whole bunch of different variables that are happening on their farm and to turn that information around quickly. If we don't develop computer programs for home computers or for terminals that are going to address those problems my feeling is that we are just dealing with a game operation. But I'd appreciate a comment on that from Mr. Parker, in particular.

My other question has to do with the challenge that I think that Mr. Norris put to us, not necessarily with regard to the design that he was putting forth, but what we see on the panel here, with the exception of Mr. Parker, are public sector personnel. To what extent should the private sector be providing this kind of advice, not so much in competition with the Extension Service but complementing the Extension Service?

Mr. Firth - I don't have the answer to the question regarding the proper mix of private sector and public sector. If we look at the Extension program, it must be educationally based. There is a fine line between education and service. I think some service work from our public sector, i.e., Extension Service, is probably in vogue and would be generally acceptable, if it would complement the educational function. It gets to be a very, very fine line. I do not have the answer to your question; it's a good one!

CONCLUDING REMARKS

Essex E. Finney, Jr., Assistant Director
Beltsville Agriculture Research Center

On behalf of Dr. Putnam, the Center Director, and the members of the Symposium Committees, I wish to express our gratitude for your participation in this Special Symposium. We have benefited immeasurably from your participation. We hope that you have gained new ideas, made useful contacts, and developed better insights into the opportunities for enhancing the viability of small farms in the agricultural industry and the economy.

Based upon the presentations made over the past 3 days, one might summarize the research needs of small farmers under three general areas: mechanization, management, and marketing. These three themes have been stressed repeatedly by our speakers and members of the wrap-up panel.

Mechanization. A number of speakers mentioned the need for the development of specialized, energy efficient equipment and machinery for small farms. Labor-saving machinery is especially important to those part-time farmers who have other employment and therefore must make the most productive use of the time available for farming in the evenings and on weekends. In many cases, the need is not simply for scaled-down versions of large machines, but for equipment to cultivate and harvest high value specialty crops. Machinery and equipment must be designed to fit efficiently into the total production and cultural system. Thus, engineers, economists, and crop specialists need to work cooperatively to better define and optimize the overall production system to achieve both efficiency and flexibility.

Management. Effective management is essential for the economic survival of small farmers. Good management systems require a continuous flow of reliable information on recommended cropping practices, soil fertility and conservation measures, pest control methods, cropping rotations, weather trends and forecasts, variety selections, and planting recommendations for local conditions. To be competitive, small scale producers must make intensive use of their limited resources of both land and capital. Thus, the research and extension systems need to deliver current information that is appropriate for a variety of local conditions. A number of speakers noted the opportunity to use computer information systems more effectively to address the management needs of small farmers.

Marketing. A third theme which has been repeated during this symposium is the need for improved methods for marketing commodities from small farms. Production plans must be closely integrated with a well planned system for marketing the end products. Many small farmers are successful producers, but are frustrated by their inability to find adequate markets for their crops and livestock at reasonable prices following production. This is especially critical for small-scale horticultural growers who must find quick markets for perishables such as berries, peaches, tomatoes, and selected vegetable crops. Research and extension programs need to provide increased emphasis on alternative marketing strategies, especially focused upon the unique problems facing the various kinds of small-scale producers.

In conclusion, the sense of this symposium is that the small farmers do and will continue to play an increasingly important role in American agriculture. They are especially important as producers of high value specialty crops and are becoming more important as providers of fresh horticultural products for direct sale at local area outlets. Small farmers are dispersed across the Nation and provide a measure of diversity and security to the U.S. food system. Many are located near major population centers where their products can be marketed directly to consumers, thereby minimizing the transportation and marketing costs which normally are extracted by the "middle man." The USDA research and extension systems need to recognize and address more fully the particular or special problems faced by small farm operators. This symposium has served to facilitate the exchange of information between scientists, producers, and other interested parties. We hope that this dialogue will be continued and, by each of our individual efforts and in concert, strengthen this important segment of American agriculture.

Thank you for your participation.

INFORMATION DISSEMINATION: A NATIONAL CLEARING HOUSE FOR SMALL FARMS

Samuel M. Leadley 1/

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ABSTRACT

Small scale farmers in America can be characterized by their diversity; yet they often share problems related directly to their small size. A variety of organizations have developed special programs for small farms. These organizations include academic institutions; private, non-profit organizations; and governmental agencies.

While the diversity in sponsors for small farm programs has advantages, it also makes communication difficult. Much of the experience and information developed through special programs becomes available to a limited audience only.

A national Small Farms Information Clearinghouse could fill this gap by obtaining, categorizing, and disseminating information related to small farms.

Keywords: Clearing house, communication, dissemination of information, information, research, small farms, small-scale agriculture.

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Small scale farms in America can be characterized by the word diversity: they produce a broad range of commodities, use conventional and/or alternative cultural practices, work land of varying quality, and span the range of income levels from limited resource to affluence. Yet they often share common problems related directly to their small size. To meet these unique, size-related problems, programs have been developed by organizations as diverse as small farms themselves to disseminate information and provide technical assistance for increased production and income. In this poster presentation and brief paper, we outline the range and diversity of organizations providing assistance to small farms, discuss some implications of this diversity, and suggest the need for a national small farms information clearinghouse.

Most organizations with programs for small farms can be included in one of four categories: academic institution; governmental agency; private non-profit organization; and private, profit-making organization. Among the academic institutions, land grant universities have research activities related to small scale agriculture; and in many states they also have developed extension programs, individually or with other universities, to work directly with small scale and/or limited resource farmers. Examples of this direct outreach approach include the Missouri Small Farm Family Program, the Allegheny Highlands Project in West Virginia, and the Tri-State Small Farms Project in Connecticut, Rhode Island, and Massachusetts. Other land grant university programs have limited outreach efforts and focus on providing support services to faculty or external organizations. Two such programs are the California Small Farm Information Access Council and the Penn State Small Scale Agriculture Center.

Many government-related and private universities and colleges have also initiated small farm programs for their students which may include research efforts, internships, and classroom instruction. Evergreen State College in Washington and Western Michigan University have, for example, established programs concerned with small farms and homestead self-sufficiency.

This diversity in program sponsorship among academic institutions is repeated in government programs for small farms. Governmental agencies at local, state, regional and national levels, often in connection with land grant universities or other institutions, have developed small farm projects which include special conservation assistance programs, direct marketing projects, and special loan programs.

In the voluntary sector, private, non-profit groups with programs for small farms include such diverse bodies as those concerned with policy and research (e.g., National Rural Center), cooperatives (e.g., Federation of Southern Cooperatives), and local self-reliance and organic agriculture (e.g., Farralones Institute Rural Center, in California). Finally, there is the private, profit-making sector which provides technical assistance and/or loans to small farms in an attempt to combine social responsibility with an acceptable profit. Rural Ventures, Inc., (Princeton Small Farms Program) and some community development corporations are examples of this orientation.

These, then, are the kinds of organizations involved in dissemination of information and technical assistance related to small farms. They are both government and privately sponsored, are local and national in scope, and are directed towards individuals and groups. There are some advantages to this heterogeneity: programs are often tailored to meet local needs and thus can respond more appropriately to the individual and local situation. There can also be more individual participation in policy setting and program delivery.

On the other hand, this diversity in program sponsorship makes communication difficult among organizations interested in small farms. The result is often that considerable amounts of time and money are spent both learning lessons already learned by others and also identifying information sources readily available to those who know where to look. And it means many of us are answering requests for the same information time and again. Moreover, much technical and organization experience is lost. Finally, the synergistic effect emerging from communication among diverse groups working on common problems is generated only on special occasions, for instance at conferences such as these.

There are, of course, formal and informal communication networks among those interested in small farms. This symposium offers one opportunity to share information and to establish contacts with a wide range of individuals. And long grant universities can tap the USDA CRIS system for information, as well as communicate through the USDA Small Farm Newsletter. But private organizations are less likely to have access to these networks. More common is the situation in which each type of agency--academic, governmental, and private--has its own closed network and communication system. To take advantage of the wealth of experience and information on small farms which now exists, a vehicle is needed for regular and systemmatic collection and dissemination of information; this vehicle should be available to all kinds of organizations interested or active in the area of small scale agriculture. A national Small Farms Information Clearinghouse could meet this need. Its function would be to obtain, categorize, and disseminate information related to small farms. It might be a loosely-structured membership organization, with contact in all segments of agriculture. It should have access to information about both research and outreach efforts and might most easily be established if attached to an existing small farm program or institution.

Given decreasing funding opportunities, this clearinghouse should be self-supporting. Funds might be obtained, for instance, from membership fees and for clearinghouse services, such as information searches and newsletters. It might also function as a central marketing facility for publications related to small scale agriculture.

A resource of this kind is needed now, and the efforts to bring it into existence should begin now while momemtum is high and interest is strong.

MEDIA APPLICATIONS IN MARKETING - A TIME TO BE INNOVATIVE

George B. Roche 1/

ABSTRACT

Understanding the realization that many small farms, not tied together cooperatively, are relegated to relatively obscure markets has necessitated much rethinking of basic marketing principles. Opportunities for direct marketing have opened the doors for creative use of media, especially the public service sector.

After a thorough reexamination of the term "medium," Maryland Department of Agriculture marketing specialists concentrated on a service to help consumers and commercial buyers locate farm supplies of Christmas trees, sod, fruit, vegetables, hay and straw. The reverse process was used to develop outlets for fruit and vegetables including horseradish. Media use ranged from TV, radio and the press to shopping malls, libraries, trade organizations, tourism and Extension Service vehicles.

New ideas are often derived from old fundamentals.

Keywords: Marketing, media, small farms, marketing specialists, direct markets, promotion, produce, new markets, Maryland.

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Accessing and utilizing media, as a marketing strategy, is a process whose purpose is essentially unchanged from the turn of the century. However, everything else has changed drastically. Due to the enormous cost of reaching the general public audience in a given area through the primary commercial channels, users or potential users have been forced to rethink purposes, methods and goals.

Access to the public through the traditional marketing channels has become more limited for the small farm operator simply because the structure of the marketplace changed. The small farmer found himself becoming excluded from the strong markets. His mobility to meet the requirements of large volume buyers relegated him to channels out of the mainstreams of produce flow.

The changing structure of the marketplace in both the demand and supply side has left small farms relegated to look for new opportunities. We must look for new ideas, new gimmicks and new methods. "Media," the plural of "Medium" 1. something lying in a middle or intermediate position: as a: a middle way: compromise... 3: something through or by which something is accomplished, conveyed or carried on... a channel, method, a system of communication, information, or entertainment... 9a. the material or technical means for artistic expression." 1/

The observations and foundation laid out,my approach followed the premise (an old principle) that people want our products - how can we help them find them. We found great interest by the public in this service while, at the same time, new markets were created for many small farms.

Our oldest and still most popular programs include the "Choose and Cut Directory of Christmas Tree Growers" which lists necessary information for the consumer such as products, telephone numbers, directions, hours of operation and other conveniences. The program provided transition from an almost extinct local industry formerly reliant upon a wholesale terminal type market. As fuel costs began to soar, the competitive edge for out-of-state trees was weakened. To recover the lost wholesale market, a telephone hotline and listing of trees was instituted for buyers and sellers. A few years ago the industry of some 30-40 businesses grew to more than 150 businesses.

The method used was official notice to radio, TV and press in sufficient time to encourage editorials. Needed is more market intelligence about media's special needs and how they view their audiences to fit the publicity results desired. We later discovered that our overwhelming telephone and postage costs could be greatly reduced by utilizing our county library distribution system - a new medium for us. Farmers must cover the cost of printing.

The "Pick-Your-Own and Direct Farm Markets in Maryland" directory and distribution program essentially uses the same media including the free library distribution. Recently, our major Tourism Information Kiosks stocked the directories - another medium.

In the past,and at a growing rate,covered shopping malls were effectively utilized to promote agriculture. We have involved sod producers with other agricultural groups to create exhibits to introduce the concept of installing your own "Instant Lawn Carpet." A new leaflet, "Pick-Up your Own Sod" was provided.

By experience and adjusting, we gradually developed an attractive package tie-in whereby the talents of shopping mall merchants were working for us. Agriculture groups paid the cost of exhibits, personnel and insurance, while the mall used the agricultural message in advertising and provided a "New Image" environment for Maryland farmers to promote themselves.

Small farms in Maryland are especially fortunate to have "Up-On-the-Farm" a Maryland Center for Public Broadcasting news formated TV show. Agricultural news, weather, prices and short features are broadcast live weekly.

Recently a hay and straw directory "Operation Maryland Haylift" was developed specifically to meet the needs of small buyers and sellers. Two lists are developed from mail responses to news releases distributed in early fall and again in mid-winter.

The Eastern Apple Committee and its advertising programs are a direct outgrowth of an original Maryland program to utilize stadium crowds and sports advertising programs for our message. Other special events such as store grand openings provide vehicles for effective tie-ins, especially when the store can offer superior talent and image. This summer, a major Baltimore department store located in a new mall combined fresh fruits, vegetables and canned goods in a ten day promotion program - an exciting new medium.

Communications in industry house organs are another opportunity. We are co-sponsoring a retail advertising and display contest with the Mid-Atlantic Food Dealers Association and will use their communications contacts to locate potential prospects to cooperate in considering a new fresh produce marketing facility. That facility could provide handling, quality control, sales and distribution for small farms produce. Such a program is in the initial stages of development. One benefit of the project will be a list of commercial produce growers and buyers. The list should be available in spring or summer of 1982.

Many small farm interests have been promoted simply by releasing ideas for the press to develop. Some latest results in this area include locating over 90 area farmers to produce horseradish and several other prospects are considering the possibility of a rabbit processing plant.

New ideas can often be derived from a return to basics and rethinking old principles.

1/ "Webster's Third New International Dictionary," 1976, G & C Merriam Co., Springfield, Mass.

Organic Waste and Residue Management on Small Farms

Sharon B. Hornick [1]

ABSTRACT

Many small farms have portions of their farmland standing idle or producing limited crop yields due to physical and chemical soil limitations. These limitations include poor soil type and structure, steep slopes, severely eroded areas caused by wind, water, or adverse weather conditions, poor crop management practices improper tillage methods, etc. The possibility of restoring these lands to a more productive status and increasing their income for the small farmer can be achieved by utilizing various organic wastes, both off-farm and on, to improve soil physical properties such as structure and drainage, and soil chemical and biological factors such as soil fertility and microbial populations. To maximize the beneficial effects that organic wastes and residues can provide, proper crop rotation practices should be followed in order to minimize insect and disease problems. The challenge is to identify if and how various organic wastes and residues differ in their ability to improve productivity and which management techniques will prove to be economically feasible and yet environmentally sound for the small-scale farmer.

Keywords: Crop rotation, organic residues, organic wastes, small farms, soil fertility, tillage methods.

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The beneficial effects that can be provided by various organic wastes such as sewage sludge compost, animal manures and other organic residues such as green manures to improve crop production and soil fertility have been well documented (1,2,3,4). Generally, organic materials provide much needed plant nutrients and organic matter which is usually lacking in low producing soils on small-scale farms. The low productivity of some of these small farms can be directly attributed to poor soil conditions resulting from an inherently poor soil type or improper tillage method, and improper crop management. Extensive loss of soil organic matter from intensive cropping and tillage practices usually causes a deterioration in soil physical properties, decreases productivity and increases erosion. Addition of organic wastes and residues can result in better crop establishment and yield, avoidance of moisture stress in crops, and the reduction of soil erosion through increased aggregation and infiltration.

Organic wastes, such as sewage sludge compost or animal manures, can contain 40 to 80% moisture, respectively. When added to soils, especially sandy soils, soil crusting is reduced and moisture retention is increased. The amount of soil moisture found in the plowlayer is directly related to the type and amount of waste incorporated. In experiments performed on revegetated sand and gravel spoils existing on a small farm, various rates of manure and compost were added. The type of waste affected the percent soil moisture as follows: the control, 7%, 40, 80 and 160 mt/ha compost, 10, 12 and 15%, respectively; and 40, 80 and 160 mt/ha manure, 15, 19 and 32%, respectively. In sandy soils or under droughty situations these higher soil moisture contents can alleviate moisture stress in crops. Soil temperature measurements on these plots also showed that the addition of organic materials resulted in much lower afternoon soil temperatures at the four inch depth when compared to the control plots. High soil temperature can be a critical factor in impeding seed germination and emergence.

Since wastes differ in their composition, all organic wastes or residue additions made to farmland cannot be handled exactly alike. Besides differences in elemental and cellulosic composition, the actual effects of different organic wastes and residues on soil microbial activity, nutrient degradation, and, hence, nutrient availability to the plant is not fully understood at this time and requires further study. If large amounts of organics are added to a small farm system to provide fertilizer versus conditioner benefits, then nutrient adjustments or supplementations may be required. Sewage sludge composts may require additional potassium, animal manure may require additional phosphorus, and incorporation of crop residues may temporarily upset microbial activity and mineralization of nutrients due to unfavorable carbon to nitrogen ratios. Most of these "problems" are easy to correct and can be minimized through proper crop rotation and management practices. In addition, the wise use of crop rotations such as corn or wheat versus alfalfa or soybean should require little fertilization, minimize nutrient losses in the soil profile, and maintain the soil-plant system with little additional fertilizer input.

Tillage practices affect the benefits which organic material can provide, the movement of water into the soil profile, the overall soil structure, and the ability of roots to penetrate the soil profile and utilize the nutrients. In the initial upgrading of an unproductive small farm, machinery such as a subsoiler could be used for deep placement (19 inches) of organic wastes. This would enable deep-rooted crops to penetrate heavy clay subhorizons and, thus, fully utilize nutrients and water stored in the organic materials and soil profile. Later tillage can be done with a chisel plow versus a moldboard plow to increase water infiltration and storage and keep the organic materials and nutrients at the surface soil level - available for plant uptake.

If the utilization of organic wastes such as sewage sludge, animal manures, food processing wastes, and the like can be coupled with additional farm conservation practices such as crop rotation, and proper tillage practices, many nutrients essential for plant growth can be kept at the soil surface for immediate incorporation into the plant. In addition, proper crop rotation can minimize the use of herbicides and insecticides once necessary for crop production. Further research and study on the proper combination of rate and type of organic waste with conservation crop management practices could provide a greater income for the small farmer and at the same time maximize harmonious and sound agricultural principles.

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FARMING SYSTEMS RESEARCH:

A POTENTIAL MEANS OF TECHNOLOGY DEVELOPMENT AND TRANSFER

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ABSTRACT

Farming Systems Research (FSR) is an on-farm centered, holistic, interdisciplinary approach to technology development for small farms. Emphasis is on an understanding of the farmer's relationship to his technical, economic, and social environment and technologies which are compatible with it. Farmers and extension workers are full partners in the research process. Most current FSR programs are located in developing countries, but there are closely related programs underway in the United States. More can be expected.

Keywords: Agricultural development, agricultural research, extension, farmers, farming systems research, small farms, technology.

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INTRODUCTION

Farming Systems Research (FSR) is one approach to the on-going problem of developing and disseminating improved technologies for small farms. It is the embodiment of a bottom up strategy in which the research process begins at the farm level with an analysis or diagnosis of farmers' constraints and then uses that analysis to determine research priorities (4). The concepts presented in this paper are synthesized from a number of sources, many of which are not published (1) (2) (4) (5).

The FSR approach recognizes that the farming system--the existing combination of resources employed and of production activities followed--is social and the farm family's response to its total economic environment. The approach technical is holistic in that proposed technological innovations must be designed for compatability with that environment. It is also interdisciplinary in that the skills of technical and social scientists from several disciplines are required

- at the level of understanding the interplay of the system's human and technical components, and
- at the level of designing and testing possible technical improvements to the system.

Equally important, FSR is interdisciplinary in that the farmer and the extension worker act as full partners in the design and testing of the proposed technology.

MOTIVATION FOR FSR

The application of the complete package of the FSR approach is today largely confined to developing countries. Many of these countries inherited, from the colonial period, research and extension structures which were designed to serve a highly commercialized, export orientated and professionally managed agriculture. They were not well equipped to serve the small, largely subsistence farms which dominate these countries' food crop sectors.

In order to increase food production for their rapidly growing populations, many countries attempted to adopt the research and extension concepts which have worked so well in the developed countries. However, publicly supported research and extension institutions are only part of the environment of technological change in the developed countries. Other essential elements include efficient product and input markets and well developed educational and transportation systems. These complementary infra-structures are missing or weak in the developing world, and the FSR approach was devised to compensate for their absence.

COMPONENTS OF THE FSR APPROACH

FSR is a complement to, and not a substitute for, disciplinary and commodity research programs. The spectrum of FSR activities is wide ranging. At one end the results of disciplinary and commodity research are used to seek solutions to major environmental constraints inhibiting agricultural progress in broad ecological zones. The FSR work of the international research centers (International Rice Research Institute (IRRI), International Crops Research Institute for the Semi-Arid Tropics (ICISAT), Centro Internacional Mejoramiento del Maiz y Trigo (CIMMYT), etc.) and some of the regional research agencies such as the Centro Agronomico Tropical de Investigacion y Ensenanza in Costa Rica is largely of this type.

At the other end FSR focuses on farm level research to improve farming systems in geographically smaller, more narrowly defined environments. Programs of this nature are conducted primarily by national research agencies. Those in the Instituto de Ciencia y Tecnologia Agricolas in Guatemala, the Institut Senegalais de la Recherche Agricole in Senegal, and the All India Coordinated Research Project for Dryland Agriculture are examples.

A description of the common elements of farm level FSR programs is most useful for capturing the essence of the approach. Gilbert, Norman, and Winch (1) have laid out:

"Four stages of research which can be delineated as follows:

"The descriptive or diagnostic stage in which the actual farming system is examined in the context of the 'total' environment--to identify constraints farmers face and to ascertain the potential flexibility in the farming system in terms of timing, slack resources, etc. An effort is also made to understand goals and motivation of farmers that may affect their efforts to improve the farming system.

"The design stage in which a range of strategies are sic identified that are thought to be relevant in dealing with the constraints delineated in the descriptive or diagnostic stage.

"The testing stage in which a few promising strategies arising from the design stage are examined and evaluated under farm conditions, to ascertain their suitability for producing desirable and acceptable changes in the existing farming system. This stage consists of two parts: initial trials at the farm level with joint researcher and farmer participation, then farmer's testing with total control by farmers themselves.

"The extension stage in which the strategies that were identified and screened during the design and testing stages are implemented.

They point out that there can be overlap among these stages, and in their further discussion they emphasize:

1. Farmer participation in the research process helps assure the relevancy of new technologies to the farm family's goals and objectives.

   These may be quite different from those traditionally regarded as paramount by agricultural scientists.

2. Extension prticipation in order to draw upon the familiarity of the extension worker with the local scene, to enhance his knowledge of the new technology, and to promote a farmer-extension worker dialogue.

3. Built-in backward linkages among the identified stages provide continuous evaluation and re-evaluation of the proposed innovations.

4. Interdisciplinary research teams enhance 1) the understanding of the way technical and human factors interact within the system and 2) the likelihood that new technologies will be tailored to the competitive, supplementary, or complementary relationships among resources and enterprise.

APPLICABILITY TO U.S. RESEARCH AND EXTENSION

There is consensus that the technological needs of small farms differ from those of larger, solidly commercial farms in the United States (3) (6). The use of the FSR approach to serve U.S. small farms is dependent upon the perception of researchers, extension workers, and administrators that

1. FSR is as technically, administratively, and financially effective as are more standard approaches, and

2. FSR is compatible with the objectives of the institution and its staff.

The Institute of Food and Agricultural Sciences of the University of Florida is one institution at which agreement on these two points is being reached. The Florida program originated from a legislative mandate in the early 1970's to develop programs for the state's small low resource farms.

The substantive portions of the program are a graduate level minor in FSR/ E and the research and extension element focusing on a five-country area in North Florida. Work with small farmers in that region is just getting underway, and Florida A&M University is cooperating in that effort. A more detailed description of the Florida program was given in a paper by Art Hansen, "Overview of the Potential Applicability of Farming Systems Research to U.S. Small Farms and U.S. Research and Extension."

A USDA Initiative

Another new program is that of the South Central Small Farm Research and Extension Center recently established by ARS Southern Region at Booneville, Arkansas. Plans for this center were discussed by J.S. Gifford in "Evaluation of Farm Systems Research in Relation to the South Central Small Farm Research and Extension Center Program."

The center's program, though not emphasizing on-farm research and not having a social science input to its core staff, appears to resemble those FSR activities aimed at developing prototype solutions to constraints identified for a broad ecological zone. In the center's case this zone is the interior highland parts of 10 states from Missouri to Georgia. The development of mechanisms to obtain explicit farmer input into the determination of research priorities is part of the center's development plan.

Other research and extension programs containing elements and/or the philosophy of FSR are underway. Increased interest in employing the approach can be expected. Motivation will come particularly from U.S. scientists' involvement with the expanding numbers of FSR programs being implemented overseas.

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PARASITIZATION OF THE MEXICAN BEAN BEETLE (COLEOPTERA: COCCINELLIDAE) BY *PEDIOBIUS FOVEOLATUS* (HYMENOPTERA: EULOPHIDAE) IN URBAN COMMUNITY VEGETABLE GARDENS

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ABSTRACT

Parasitization of the Mexican bean beetle (MBB), *Epilachna varivestis*, by the chalcidoid wasp *Pediobius foveolatus* (PF) was monitored in five urban vegetable gardens in Washington, D.C. in 1979 and 1980. We inoculated all five gardens with PF in 1979 and one of these gardens in 1980. PF is an exotic, nonoverwintering biological control agent that is used in Maryland soybean fields. Our inoculative releases, PF that probably came from Maryland, or both parasitized from 97 to 100% of the MBB larvae in each garden by late summer. Thus, much of the MBB damage in these urban gardens probably could be eliminated by making inoculative releases of adequate numbers of PF throughout gardens at appropriate times.

Keywords: Beans, biological control, Mexican bean beetle, *Pediobius foveolatus*, small farms, urban vegetable gardens.

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The Mexican bean beetle (MBB), *Epilachna varivestis* Mulsant, an important pest of beans and soybeans throughout continental United States, can be controlled by the exotic chalcidoid wasp *Pediobius foveolatus* (Crawford) (PF). Unfortunately PF appears unable to overwinter in temperate regions and must be released each year for utilization in biological control. Annual inoculative releases of PF have been made in Maryland soybean fields since the early 1970s (4). Although this wasp is a valuable biocontrol agent in soybean fields, it has not been previously used in other situations, e.g., vegetable gardens, before we initiated our work in 1979.

In community vegetable gardens in Washington, D.C., MBBs can totally defoliate bean plants by midsummer if control measures are not taken. Gardeners frequently apply chemical pesticides to control these beetles, increasing the pesticide pollution in this city. The pesticide load in Washington, D.C., has not been ascertained but may be greater than that in surrounding agricultural areas as in other cities. Despite the pesticide use in Washington gardens, this wasp commonly parasitized MBBs in fall 1977 and 1978, but this was after MBBs had significantly damaged beans. No one is known to have released PF in this city before 1979; therefore, it probably entered the city from Maryland soybean fields. It can move at least 160 km in one season, most likely being carried by wind (2).

In this study, we attempted to assess the ability of PF to control MBBs and further biological knowledge of insects in urban gardens in general. PF were released and monitored in 1979 and 1980 in Washington, D.C. Notwithstanding the prevalence of urban "vegetable patches" and the value of their produce in the United States, there are almost no investigations that deal primarily with their beneficial and pestiferous arthropods (3). Such studies should help to reduce the use of unnecessary, polluting pesticides in urban areas. The following is a detailed summary of a report of our work that is presently in press (1).

MBBs and PF were obtained from the Maryland Department of Agriculture, College Park, in 1979. Beetles were reared on leaves of bush bean, *Phaseolus vulgaris* L., and were used as hosts for PF. To rear wasps, mated females were placed in petri dishes with 4th-instar MBB larvae and they usually parasitized all of the larvae within 24 h.

Fifty mated, 2- to 6-day-old female wasps were released in late afternoon or early evening in the second week of July, 1979 and 1980, in bean patches harboring MBB larvae. Wasps were released in Northwest Washington, D.C., in the C, G, N, S, and W gardens in 1979 and only in the G garden in 1980. The gardens were from 492 to 9,338 m^2, contained from 12 to 120 garden plots, and were immediately surrounded by grassy park areas or forests. Buildings, national forests, and other parts of the city separated the five gardens. Gardeners knew that we were working on MBBs but we did not ask them to alter their usual practices in any way.

The week of wasp release is designated as week 0; the first week after release, week 1; etc. Larval collecting was initiated in a random area of from 3 to 6 sampling sites in each garden. The first older larvae that were encountered were collected to reduce sampling bias. They were maintained in paper cartons or plastic bags with fresh bean leaves until they either mummified due to PF parasitization, died from other causes, or matured into nonparasitized adults. Emerged wasps were sexed by examining them with a dissecting microscope to ascertain the percentages of males. In 1979, a mean of 10.3 MBB third and fourth instars and prepupae were collected from each sampling site from weeks 1 to 9.

In 1980, PF were released only in the G garden and the remaining four gardens served as controls (ones in which we did not release wasps). We tried to obtain samples of at least 10 third- and fourth-instar and prepupal MBBs from each of the peripheral and central sampling sites of a particular garden. Samples were obtained in weeks 4, 7, and 9 after release of PF in the G garden. When later-instar MBBs could not be found, early instars were collected and reared to ascertain whether or not they were parasitized by PF. They prefer to oviposit in older larvae but will parasitize younger ones when older ones are scarce.

In 1979 no parasitism of MBBs by PF was detected from samples that were collected in week 0. In week 1, there were from 0 to 55 parasitized MBBs per release site (15.6 ± 10.33 SE, n = 5 gardens). Even though gardeners inadvertently removed beans at two sites and applied a pesticide dust at one of the other release sites, the PF population increased in each garden, causing 100% of parasitism in sampled MBBs in week 3 (C garden), week 7 (N), and week 8 (W and S). In week 9, 98% parasitism occurred in the G garden. In all, 217 samples of from 1 to 16 MBB larvae were examined. Percent parasitism was positively correlated with time ($p = 0.01$, Kendall rank correlation test). Data from 1980 revealed that PF from Maryland may have entered two of the control gardens as early as mid-July. Therefore, PF that we released in gardens in 1979 may have been supplemented with ones from Maryland. In 1979 by week 2 or 3, the highest percentage of parasitism was in sampling sites nearest to or second nearest to the release sites, suggesting that our released PF were the only ones or the most frequent ones in gardens in weeks 2 and 3 and possibly later.

From July to September 1979, the area planted in beans decreased from 46.7 to 80.6% (62.1 ± 7.66) in all five gardens. Based on our discussions with and observations of gardeners, there are two main reasons for this decrease. First, many experienced gardeners do not plant a late summer bean crop because they remember high populations of pestiferous MBBs at this time in past years. Second, many less-experienced gardeners tend to decrease the time that they spend gardening and plant fewer vegetables as the season progresses.

In 1980, MBBs were sampled for PF parasitization in weeks 4, 7, and 9 after their release in the GP garden. There was no significant difference in average frequency of parasitism between years in all five gardens in these 3 weeks ($p < 0.05$, test for equality of two percentages) even though PF were released in only one garden in 1980. On the other hand, in individual gardens, percent parasitism was significantly different nine times between years. In week 4, the percent parasitism in the S garden was even significantly higher ($p < 0.001$) than that of the G garden. Either a founding population of PF moved into the S garden, they overwintered in or near the garden, or both. If PF cannot overwinter in the city, many if not all of them that founded subpopulations in the C, N, S, and W gardens probably came from Maryland, the G garden, or both. Wasps reduced MBB numbers earlier in 1979 than in 1980 in the C and W gardens. From week 9 until killing frosts, new bean leaves without MBB damage were frequent in both years. In 1980 in week 14 post wasp release, no living MBB larvae could be found and the bean plants were thriving.

In conclusion, our study suggests that if PF were introduced into urban gardens at the appropriate time (e.g., late June in Washington, D.C.), summer and fall beans would have few or no MBB larvae. This should encourage gardeners to increase garden productivities by planting more beans from mid- to late summer. Moreover, using PF as a biological control agent could significantly reduce use of possibly injurious chemical pesticides in these gardens because the MBB is a chief pest that the gardeners try to control with these pesticides. This beneficial wasp also fatally parasitized a minor pest, the squash beetle, E. borealis (F). Thus, PF should be widely used by gardeners wherever MBBs and squash beetles are problems.

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COMPOSTED SLUDGE AS A SOIL AMENDMENT FOR CONTROL OF SOILBORNE PLANT DISEASES

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ABSTRACT

Sludge compost was added to different soils (10%) individually infested with eight important soilborne pathogens. Diseases caused by these pathogens on various crops were assessed in the greenhouse. Aphanomyces root rot of peas, Phytophthora blight of pepper, Rhizoctonio root rot of bean, cotton and radish, and Schlerotinia drop of lettuce were decreased significantly by addition of compost to soil. Pythium damping-off of bean and pea was affected variably or was increased by compost. Fusarium root rot of pea and Thielaviopsis root rot of bean were increased also. Field studies indicated significant reduction of lettuce drop within the first year of compost addition. Pythium damping-off of peas was not reduced initially, but, it was reduced drastically in compost-amended plots one year after compost amendment. The results indicated a significant reduction in occurrence of certain soilborne diseases by compost, especially after long term incubation in soil. Biological activity and populations of antagonistic microorganisms were also greater in compost-amended soil than in non-amended soil. The observation of disease reduction in the field adds to the list of horticultural and agronomic benefits of sludge compost in agriculture. Increase in some diseases by addition of compost requires consideration and studies on management of compost addition to soil need to be done to eliminate this as a problem.

Keywords: Damping-off, diseases, root rot, small farms, sludge compost.

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Approximately 5 million dry tons of sewage sludge and septage are produced annually in the U.S. This is a national resource of large economic value, and proper and efficient utilization is important. Considerable interest in composting of sewage sludge has emerged in the past decade and is continuing. The composted sewage sludge is used in land reclamation and in the production of horticultural mulches and in turfgrass. Since large amounts of sludge compost inevitably will be added to agricultural soils, it is of major concern to determine the effect this added compost will have on diseases of plants growing in the amended soils. Recent research has indicated benefits of compost to soil tilth and fertility as well as to crop yield and plant vigor (1). Few studies, however, have demonstrated the effect of sludge compost on soil microorganisms which cause diseases of plants.

In 1978, a series of greenhouse experiments was initiated to determine how sludge compost affected 10 different soilborne diseases on six crops (pea, bean, pepper, cotton, radish, and lettuce) with eight pathogenic fungi (species of *Aphanomyces*, *Fusarium*, *Phytophthora*, *Pythium*, *Rhizoctonia*, *Sclerotinia*, and *Thielaviopsis*) (2). Soils (sandy loam or loamy sand), naturally or artificially infested with a given pathogen, were amended with compost at a rate of 10%. The compost, with low levels of heavy metals, was prepared at the Beltsville Agricultural Research Center. Amended, infested soils were incubated moist up to 14 weeks after amendment, planted with the appropriate crop and maintained in the greenhouse at a temperature and moisture regimen specific for each host-pathogen combination. After a suitable period in the greenhouse, ranging from 3-6 weeks, disease severity in amended and non-amended soils were assessed (Table 1).

Diseases caused by *Aphanomyces euteiches*, *Phytophthora capsici*, *Rhizoctonia solani* and *Sclerotinia minor* were reduced significantly by compost, whereas those caused by *Pythium aphanidermatum*, *P. ultimum*, *Fusarium solani* and *Thielaviopsis basicola* were unaffected or increased by the compost amendment.

Because diseases caused by *R. solani* and *S. minor* were (a) reduced dramatically by the compost, (b) cause appreciable loss to economic crops, and (c) could be studied readily in the field, plots (2.5 x 4.0 m were established in Beltsville to study the effect of these two pathogens in the field. Twelve replicate plots were infested with preparations of oats infested with *R. solani* and 12 with sclerotia of *S. minor*. All plots were infested naturally with *Pythium ultimum* and to some extent with *R. solani*. In both 1980 and 1981, one-half of the plots were amended with compost (10%, ca. 220 t/h/15 cm) and one-half were not amended. Control plots were supplemented with fertilizer (10-10-10) and limestone to equate nutrient status and pH (6.5-7.0) with compost-amended plots. In *Rhizoctonia*-infested plots, peas were planted in rows 45 cm apart, 100 seeds/3.7 m row, in the spring and fall of 1980 and the spring of 1981. In *Sclerotinia*-infested plots, 3-wk-old Romaine lettuce seedlings were transplanted 30 cm apart, 60 plants/plot, in the spring and fall of 1980 and in the spring of 1981.

Compost did not increase significantly the stand of healthy pea plants when the plots were set up in the spring of 1980 or in the following fall (table 2). In the spring of 1981, however, a dramatic increase in healthy plant stand occurred in the compost plots. Initially, we determined that the major pathogen responsible for disease of peas at each planting was *Pythium ultimum*, which occurred naturally in the soil, and not *R. solani*, as

Table 1 - Effect of sludge compost added to soil at rate of 10% on selected diseases caused by soilborne plant pathogens in the greenhouse

Pathogen	Host	Disease parameter	Unamended soil	Compost-amended soil[a]
Aphanomyces	pea	root rot (0-100%)	59	11*
Fusarium	pea	root rot (0-4)	0.1	1.0**
Phytophthora	pepper	stand (%)	3	45**
Pythium ultimum	pea	stand (%)	61	32**
P. aphanidermatum	bean	stand (%)	86	88
Rhizoctonia	bean	root rot (0-4)	2.5	1.0*
	cotton	stand (%)	31	60**
	radish	stand (%)	12	68**
Sclerotinia	lettuce	stand (%)	0	50**
Thielaviopsis	bean	root rot (0-4)	0.5	3.3**

[a] Values followed by * are significantly less than control; those followed by ** are significantly greater than control, $p = 0.05$.

intended. The populations of *Pythium* in 1980 were 947 and 587 propagules/g dry soil in the control and compost-amended soils, respectively; in the spring of 1981 they were 3979 and 814 propagules/g. The pathogen ordinarily is able to cause disease of pea at either of these levels, but was suppressed in the compost-amended soil. *Rhizoctonia*, however, occurred at a low level. A test was performed in pots to determine the effect of time sequence of compost amendment on damping-off of peas caused by *P. ultimum* in the field soil. Results showed that more damping-off occurred in soil with fresh addition of compost than in non-amended soil. However, soil amended with compost and left for one year had much less disease than the non-amended soil.

Lettuce drop caused by *S. minor* was significantly reduced in the compost-amended soils at all three planting dates (table 2). The disease reduction was greatest in the third planting, in the spring of 1981. This suggested that enhanced suppression occurred with time after amendment. No significant differences occurred in numbers of sclerotia (survival structures) of *S. minor* retrieved from the amended and non-amended soils one year after infesting with the pathogen. Also, no differences occurred in head size and weight of the lettuce plants between the two treatments.

Table 2 - Effect of sludge compost (10%) on pea damping-off (cv. Perfected Freezer) caused by *Rhizoctonia* and *Pythium*, and lettuce drop caused by *Sclerotinia* in the field

Disease	Healthy plants (%)		
Soil treatment	Spring 1980	Fall 1980	Spring 1981
Pea damping-off			
none	11 a[z]	12 a	0 a
compost	17 a	29 a	24 b
Lettuce drop			
none	30 b	76 b	86 b
compost	50 a	88 a	97 a

[z] Values in each column for each disease followed by the same letter do not significantly differ, *p* = 0.05.

From these results an immediate beneficial effect in the reduction of diseases caused by *Rhizoctonia*, *Pythium*, and *Sclerotinia* is evident. This beneficial effect may be enhanced by the repeated application of compost or by allowing compost to decompose for long periods in the soil. The time between amendment and planting was very important with diseases caused by *Pythium* spp. The apparent ineffectiveness of compost in short term pot tests to reduce disease in the greenhouse was obviated by long term incubation of compost in field soil. Disease was reduced greatly in soil containing compost for one year. In addition, we have detected larger numbers of antagonistic bacteria and actinomycetes and greater microbial activity in the compost-amended soils than in the non-amended ones. It appears likely that the high biological activity of these beneficial antagonists associated with decomposing compost in soil effectively reduces the activity of certain soilborne plant pathogens and subsequent disease. This added benefit increases the value of compost for application to agricultural soils. Other pathogens may be stimulated by addition of compost and we should be aware of this as a potential problem.

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SHEEP PRODUCTION SYSTEMS FOR SMALL FARMS

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ABSTRACT

Nationwide, sheep numbers have declined from 50 million head in 1942 to a current level of approximately 12 million head. Increased production of sheep is a distinct potential of the Northeast region due to thousands of acres of marginal land which is currently under-utilized but may be suitable for forage production. Sheep are especially adapted to utilize these forages and can be produced with minimal amounts of grain and specialized equipment. However, integrated, low cost systems of plant and animal production are needed. Such a cooperative project was initiated with research team members from the Departments of Dairy and Animal Science, Agronomy and Agricultural Engineering, and the U.S. Regional Pasture Research Laboratory, all located at University Park, PA. Research areas being studied include: the evaluation of four pasture systems varying in level of agronomic and managerial input; the intake and digestibility of resident plant species on unimproved marginal lands by sheep and goats; and the development and evaluation of several sheep fencing, watering and housing systems. Results to date have indicated an approximate four-fold increase in animal productivity for an intensive versus extensive pasture establishment and management program. Further, more efficient utilization of pastures containing browse material has been noted when co-grazing sheep and goats. Utilizing solar and wind power for fencing and watering systems appears to have considerable potential for small farm forage/animal programs.

Key words: Sheep production, goats, marginal land, pasture systems, sheep facilities, fencing, small farms.

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On many small farms a high percentage of the land has inherent restrictions to growth of cultivated crops and throughout the Northeast under-utilized land is common. Growth of forage crops and their utilization through sheep offers an alternative use of land unsuited for production of cultivated crops. However, economic resources are limited in many small farm situations and to insure low-cost sheep production, machinery and other crop-production costs must be minimal. Techniques for establishing improved forage species and improving low producing pastures wihtout the use of expensive seeding equipment and large amounts of fertilizers and herbicides are required. Further, improved low-cost fencing, housing, and watering facilities which are adaptable to remote, marginal land areas are needed.

To meet these objectives, a cooperative project was initiated involving personnel from the Departments of Dairy and Animal Science, Agronomy. and Agricultural Engineering, and the U.S. Regional Pasture Research Laboratory, all located at University Park, PA. The key research areas are briefly outlined below.

PASTURE SYSTEMS

A 25-acre marginal land site was developed at which four pasture-production and utilization systems are being tested. In the S1 and S2 systems no mowing of weeds nor mechanical or herbicidal removal of brambles, bushes, and shrubs was done and seed was broadcast on the surface. The approximate brush cover in the S1 and S2 systems was 30%. S2 is grazed by sheep and serves as the check treatment, providing information on inherent productivity of the land for sheep production on an extensive, low-input basis. In S1 goats are co-grazed with sheep affording a comparison of the relative effects on resident and seeded plant species of grazing by sheep with the combined effects of mixed sheep and goat flocks.

S3 was cleared by hand of shrubs and bushes initially. Limestone and fertilizer was applied at one-half recommended amounts and seed was surface-seeded with no soil tillage. S4 was cleared of bushes and shrubs and large weeds were mowed. Recommended amounts of lime and fertilizers were broadcast on the surface, and seed was planted with a no-till seeder. Both S3 and S4 are grazed with sheep only.

Forage species, seeding rates and fertilization rates used in each pasture system are outlined in table 1. As indicated S1 and S2 treatments were continuously grazed while S3 and S4 treatments were divided into quadrants and rotationally grazed. One fourth of the area in S3 and S4 contained only grasses fertilized with nitrogen which provided early spring and late summer (just prior to breeding) grazing. Two replications of each system were employed and the put-and-take system of grazing was used. The area of land devoted to each replication-system combination was based on a sufficient area being used to accommodate at least four tester ewes and their lambs. Tester animals were of Dorset (1/2) X Suffolk (3/8) X Western (1/8) breeding and were bred to Rambouillet rams.

Preliminary results were summarized for the first 85 trial days of the 1981 grazing season (5/13/81-8/6/81). Ewe and lamb grazing days per acre were 98, 145; 133, 195; 238, 356; and 438, 712 for the S1, S2, S3 and S4 pasture systems, respectively. Total lamb gains (lbs/acre) and rate of gain (lbs/day) were 64, .44; 80, .41; 164, .46; and 299, .42 for the four respective systems. In addition to the sheep production data for the S1 pastures, a total of 176 goat grazing days per acre were obtained. Dramatic increases in animal productivity per acre are evident as the level of agronomic and managerial input increases. Although rate of lamb gain is strikingly similar among the four systems the increased forage available manifests itself in terms of total lamb produced per acre. Hopefully, this work will be repeated for a number of years. Careful economic analyses will be required to establish the net profitability of various levels of agronomic input.

COMPARATIVE INTAKE AND DIGESTIBILITY OF MARGINAL LAND PLANT SPECIES BY SHEEP AND GOATS

To more intensively examine the effects of co-grazing marginal lands with sheep and goats, a 12-acre site was divided into quadrants, each containing approximately equal amounts of open grassland and woody vegetation. A field survey was made to estimate the important plant species and their relative abundance prior to the initiation of each of four periods of collection. Six sheep and six goats were fitted with esophageal fistulas and canvas fecal collection bags to determine plant species selected by each and their digestibility.

Table 1. -- Seeding and Fertilization Rates for Four Pasture Production/Utilization Systems

		Forage Species and Seeding Rates (lbs/A)						Fertilization (lbs/A)			
System	Grazing	Percent of System Area	Kentucky Bluegrass	Perennial Ryegrass	White Clover	Birdsfoot Trefoil	Red Clover	Lime	N	P_2O_5	K_2O
1 & 2	Continuous	100	5	10	.75	5	--	--	--	--	--
3	Rotational	25	5	10	--	--	--	1500	50	45	90
	Rotational	25	5	10	.75	--	4	1500	--	45	90
	Rotational	50	5	10	.75	5	--	1500	--	45	90
4	Rotational	25	5	10	--	--	--	3800	100	90	180
	Rotational	25	5	10	.75	--	4	3800	--	90	180
	Rotational	50	5	10	.75	5	--	3800	--	90	180

Esophageal forage samples and fecal samples are currently being analyzed in the laboratory and specific intake and digestibility data are not available at this time. However, repeated visual observations of sheep and goat grazing behavior were made and indicated a difference in the plant species preferred by each. Even when common grasses and legumes were available, goats demonstrated a preference for various browse and forbs including gray dogwood, *Cornus* sp.; thistles, *Cirsium* sp., sumac, *Rhus* sp.; and goldenrod, *Solidago* sp. In many cases, goats were able to remove the green foilage from tall growing brush and brambles to heights exceeding 6 feet. In these areas, a notable increase in the growth of common grass and legume species was observed, undoubtedly due to improved sunlight penetration.

The degree of dietary overlap between sheep and goats will depend upon relative abundance of various types of plants. However, under the conditions encountered in this trial, there appears to be little direct dietary competition between the two animal species, and goats appear to be valuable in encouraging growth of desirable forage species.

FENCING AND WATERING

Several fencing types were tested at the pasture sites. Perimeter fencing was 10-strand high-tension suspension fence while grazing systems within the perimeter were divided by an 8-strand fence. There were no problems encountered from dog penetration of the perimeter fence although it is unknown to what degree dogs attempted to enter the pasture areas. Within the S3 and S4 pasture, areas were subdivided for rotational grazing by either conventional smooth steel wire or nylon twine with interwoven steel filaments, and either wood or plastic posts. All fences were electrified with a battery-operated, solar-charged fencer.

Physical strength and rigidity were found to be important design criteria for all fences. Electrified nylon twine with interwoven steel filaments as conductors proved to be unsatisfactory for sheep. The material stretched and yielded with sheep contact and failed to penetrate wool for good electrical circuits. Conventional steel wire functioned well and minimal specifications for effective subdivision fencing for sheep include: 1) four strands of 14 gage galvanized or aluminum coated steel wire, each strand stretched and electrified; 2) wire spacings from the ground of 6 in, 13 in, 21 in, and 30 in; and 3) ridgid and firmly-set posts every 16-18 ft.

The battery-operated fencer was kept fully charged by solar energy throughout the 1981 grazing season and appears to have considerable merit for remote areas. As the research progresses, economic comparisons of all systems will be made along with observations of durability and effectiveness.

A low-cost, above ground plastic swimming pool with a 6000 gallon capacity was tested as a water reservoir. A 2-stage savonius wind turbine was made from longitudinally split 50 gallon steel drums. The turbine was mounted to a propeller shaft which provided agitation of the water within the reservoir during periods of sufficient wind movement. A peristaltic pump was also mounted on the shaft and delivered water from the reservoir to an elevated holding tank, from which pastures received water by gravity.

The wind powered stirring mechanism was helpful in maintaining water quality during the summer months. During winter months several inches of styrofoam insulation were placed on the water surface and coupled with the wind-powered agitation, prevented significant ice buildup within the reservoir.

CONCLUSIONS

Throughout the Northeast region marginal lands represent a largely untapped resource available for forage production. Sheep are ideally suited to utilize forages and can achieve market condition with little or no supplemental grain. Further, many of the key marketing areas for lamb are located within the region and provide further stimulus for increased sheep production. Realizing this potential, however requires the development of relatively low-cost sheep/forage production systems.

The research described in this report is at an early stage and should be repeated for several years so that meaningful recommendations can be made for various producer situations. However, we have already noted several significant trends. Tremendous increases in animal production per unit land area are possible with proper soil amendments, the introduction of legume species, and the use of rotational grazing. More refined management input however, must be supplied in such intensive production systems.

Secondly, it is obvious that the goat can serve as an effective companion grazer to sheep when pasture areas contain mixtures of browse and bramble cover and conventional grasses and legumes. At proper stocking rates the goat can serve as an effective means of biologically controlling undesirable plant species and allowing the desired plants to flourish.

Finally, work in the areas of fencing and watering have shown the feasibility of implementing low-cost systems. Many marginal lands are in remote areas not served by conventional water or power sources. Use of solar and wind power under these conditions is a definite option.

USE OF COMPOSTED SEWAGE SLUDGE FOR TURFGRASS PRODUCTION

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ABSTRACT

Composted sewage sludge can be used economically and beneficially in turfgrass production for various areas, including homelawns, parks, institutional grounds, athletic fields, golf courses, and roadsides. It can also be used in commercial sod production. Because of the economic aspects of small-scale and location, the suburban small farmer or gardener may have an advantage in utilizing compost. The plant growth benefits from utilizing compost are derived from its content of plant nutrients, organic matter, and liming properties. This paper discusses various uses of composted sludge in turfgrass production, including 1) its use as a soil amendment for the establishment of turfgrasses from seed or sod, 2) its use as a low grade fertilizer for maintenance of established grasses, and 3) its use as a soil amendment or growth medium for commercial sod production. Recommendations are suggested as to method, time, and rates of compost application for different soils and management practices. Some of these recommendations may change as ongoing research progresses.

Keywords: Small farms, sod production, turfgrass establishment, turfgrass maintenance, lawns, soil amendment, soil conditioner, fertilizer, organic matter.

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INTRODUCTION

Composting as a method of stabilizing sewage sludge has increased in recent years. This increase in sludge composting, the increased prices of chemical fertilizers, soil conditioners, and good topsoil, as well as the need for environmentally acceptable sludge disposal methods, have increased the interest in utilizing composted sludges in crop production. Studies conducted since 1973 indicated that sludge composted by the Beltsville Aerated Pile Method (5) can be used beneficially in turfgrass production for various areas, including homelawns, parks, institutional grounds, athletic fields, golf courses, and roadsides. It can also be used in the production of cultivated sod. The benefits from using compost are derived from its content of plant nutrients, organic matter, and liming properties. The small-scale farmer or suburban gardener is in an unique position to utilize compost in a manner that will maximize the beneficial results that can be derived from the material.

The composting process and pathogen destruction are addressed in other papers of this symposium, and, therefore, will not be addressed here. The chemical composition of sludges (and compost) vary depending on the industrial facilities and waste treatment facilities of a given location (6). Macronutrient content is not as variable from location to location as micronutrients. Nitrogen, phosphorus, and potassium contents generally range from 1 to 1.5, 1.5 to 2, and less than .5 percent, respectively. The use of compost in the turfgrass industry would reduce the amount of chemical fertilizers needed at a time when the use of fertilizers on non-food crops is being questioned for conservation reasons.

Composting eliminates or reduces a number of the limitations associated with the use of "sludge" in turfgrass production. It essentially eliminates objectionable odors and human pathogens (5). Further, composted sludge is a granular, humuslike organic material which is much more easily handled and uniformly applied and incorporated with the soil then the sludge from which it is derived.

The organic matter in compost improves the physical condition of many soils, which in turn improves plant growth (3, 4). The potential benefits of compost as a source of organic matter take on added significance as more marginal lands are being used for construction of homes and other developments, and as good topsoil becomes increasingly expensive.

The nutrient content of compost, especially the nitrogen content, and the rate of mineralization are very important when compost is utilized in turfgrass production. Nitrogen influences the rate of turfgrass growth more than other nutrients. Unlike the production of many crops, maximum growth of vegetation of turfgrasses is generally undesirable. The desirable growth rate is one which is sufficient to maintain a healthy, uniform turf during the growing season without excessive vegetation. The nutrients in composted sludge are released and become available for plant growth over a relatively long period of time. Therefore, not only would the amount of required inorganic fertilizer be reduced by the nutrients in the compost, but also the slow rate of mineralization would provide for uniform growth over a long time.

A major cost factor in the utilization of composted sludge is transportation from treatment facilities to disposal site. Since large hectorages of turfgrasses are generally located within a short distance from sewage treatment facilities, utilization on turfgrass areas may minimize this cost as well as the cost of turfgrass production.

One of the greatest potential hazards with land disposal of sludge and sludge products is the buildup of heavy metals in soil, with resulting reduction in plant growth (1) or, in some cases, high toxic metal concentrations in plant tissues that enter the food chain (2). Utilization in production of turfgrasses would be potentially less hazardous than in the production of most other crops because turfgrass is not a food chain crop. Turfgrasses are also more tolerant to heavy metals than many other crops.

Effects of Compost Additions on Soil Properties

Compost additions to the soil generally increase the organic matter content; cation exchange capacity; level of plant nutrients and other mineral elements; improve soil structure; and water holding capacity. Compost additions to marginal soils will significantly improve their physical properties. Aggregation and stability of aggregants are increased, soil aeration is increased, surface crusting is reduced, and water infiltration and retention are increased (3). Compost added to sandy soils will increase the moisture available to the plant and reduce the need for irrigation. In heavy clay soil, the organic matter increases the soil's permeability to water and air, increasing water infiltration into the profile, and thereby minimizes surface runoff. Additions have also been shown to reduce compaction, i.e., lower the back density. Application rates of compost that will supply the nitrogen requirement of most turf areas will also supply sufficient levels of all other essential plant nutrients except potassium. Potassium is not changed significantly by compost additions.

The cation exchange capacity (CEC) of "poor soils" is approximately doubled from the addition of 200 mT/ha (dry metric tons per hectare) compost. The increase in CEC is important, not only because of the effects it has on the availability of plant nutrients, but also its effect on availability of toxic metals. The higher the CEC, the greater the binding of metals and the less they are available for plant uptake. Organic matter also complexes and detoxifies excessive potentially toxic metals.

The pH of acid soils is substantially increased with compost additions. Soils with pH of 4.5 are usually increased to 6 or above when 100 to 200 mT/ha compost is incorporated into the top 10 to

15 cm of the soil profile.

Compost for Establishment of Turfgrasses

Establishment of turfgrass from seed or sod can be significantly increased on many soils by using composted sludge as a soil amendment. When compost is incorporated with the top 10 to 15 cm of the soil or applied as a mulch to the soil surface before or after seeding, seedling establishment is more rapid than with conventional fertilizer practices. Best results for germination, establishment, and initial growth rate are obtained with applications of 50 to 150 mT/ha. The lower rate is generally used on fertile soils and the higher rate on sandy soils or subsoils low in organic matter. These rates will provide sufficient nitrogen, phosphorus, and micronutrients for optimum plant growth. Potassium must be added if the soil is naturally low in this element. Additions of less than 50 mT/ha are beneficial but should be supplemented with commercial nitrogen and potassium fertilizers. Where compost applications are based on the nutrient requirements of the turfgrass, rather uniform and favorable growth rates can be expected for 5 to 6 months after seeding or sodding. Excessive growth occurs with additions greater than 200 mT/ha even on infertile soils.

The increase in rate of establishment with compost above that obtained with fertilizers can perhaps be largely attributed to improved soil physical properties.

Compost applied at 18 to 20 mT/ha (layer 1-1.5 cm thick) to the soil surface as a mulch before or after seeding can markedly increase the rate of establishment of cool-season grasses. The greatest benefits from its use as a mulch have been on late fall or early spring seedings when air temperatures are relatively cool. When used as a mulch with small-seeded grasses, such as Kentucky bluegrass and bentgrass, the compost should be applied before seeding. With larger seeded grasses, such as tall fescue, red fescue, and perennial ryegrass, the compost mulch can be applied uniformly after seeding.

Root growth of conventionally produced sod is increased when the sod is laid on soil amended with compost. Applications of 60 to 120 mT/ha, depending on the soil, and incorporated to a depth of 10 to 15 cm will significantly increase root growth and development and provide near optimum growth for 2 to 4 months after the sod is laid. Root growth is not increased appreciably with higher compost rates; however, excessive grass growth can be expected with rates higher than 175 mT/ha.

Maintenance of Established Turfgrasses

Composted sewage sludge can substitute for conventional fertilizers in the maintenance of established turfgrasses. The extent to which compost can be used to supply the total nitrogen requirement depends on the maintenance level desired. For turf on parks, institutional grounds, right-of-ways, many home lawns, and other areas under a low-to-moderate maintenance level, compost can be used to supply the total nitrogen requirement. For higher maintained, or higher quality turf, compost can be used to supply a part of the nitrogen requirement, with the additional nitrogen supplied from other sources.

The response of tall fescue and Kentucky bluegrass is best with applications of 12 mT/ha (245 kg/ha total nitrogen) in the fall or split applications of 6 mT/ha in the fall and again in the early spring (Table 1). These treatments will provide acceptable turfgrass quality for general-purpose turf and most homelawns. However, higher quality turf can be obtained by applying compost in the fall and winter at rates that would supply one-half of the total nitrogen requirement. A water-soluble source of nitrogen could then be applied when needed for added color. The use of compost on close cut, highly maintained turf, such as golf course greens and tees, may be objectionable because of a black residue.

Commercial Sod Production

The greatest potential use of compost in the turfgrass industry is probably in commercial sod production. If compost is managed properly, large quantities could be used on a relatively small land area. It can be used in sod production as a soil amendment, as discussed under establishment of turfgrasses, or as a growth medium.

When used as a soil amendment, 100 to 150 mT/ha incorporated to a depth of 10 to 15 cm, will provide good plant growth. Incorporating the compost is essential if irrigation during establishment is not practiced.

Composted sewage sludge is an ideal growth medium for most turfgrasses. The only essential plant nutrient that has to be added is potassium. Kentucky bluegrass-red fescue and tall fescue-Kentucky bluegrass mixtures seeded into a 5 to 15 cm layer (175 to 530 mT/ha) of compost on the soil surface have produced a harvestable sod within 9 months after fall seeding compared with 12 to 18 months normally required. When seeding into a layer of compost on the soil surface, irrigate to leach salts and prevent drying of the upper part. Although frequent mowing is required, the total number of mowings is about the same as with conventional sod production because the sod can be harvested sooner. Other advantages of surface applications are that little or no herbicides and commercial fertilizers are required. Moreover, compost sod weighs about 30 to 40 percent less than mineral soil sod.

Sod produced on soil amended with compost, or on a layer of compost 2.5 to 15.0 cm thick on the soil surface, had no reduction in rooting when installed on a sandy loam or heavy clay soil and managed correctly. Rooting of sod produced with soil incorporated compost was better than sod produced on a layer of compost when regular irrigation was not possible following

Table 1.—Effects of fertilizer source, rate, and time of application on turfgrass quality of Kentucky bluegrass grown on two soils[1/]

	Treatments			Turfgrass quality ratings		
	Fertilizer	Rate	Time	Sandy loam soil	Silt loam subsoil	Mean
1.	Compost------	24 mT/ha	Spring	5.8 b	4.9 bc	5.2 b
2.	Compost------	24 "	Fall	6.6 a	6.4 a	6.5 a
3.	Compost------	12 "	Sp. & Fall	6.6 a	5.7 ab	6.3 a
4.	Compost------	6 "	as needed	6.2 ab	4.7 c	5.1 b
5.	NH_4NO_3-------	146 kg/ha	as needed	6.7 a	5.8 ab	6.3 a
6.	Ureaform-----	128 "	Sp. & Fall	6.6 a	5.6 b	5.9 ab
7.	IBDU---------	157 "	Sp. & Fall	7.1 a	6.1 a	6.5 a

[1/] Quality ratings are based on a scale of 1-9; 9 = ideal turf quality. Values are averages for eight ratings per year for three years on plots replicated three times. Treatments 4 and 5 were applied four or five times each year. Values within columns followed by the same letter are not significantly different (0.05DMR).

installation. The soil-compost sod is heavier and makes better contact with the soil surface than compost sod.

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PLANT PATHOGENIC FUNGI IN COMPOST/SOIL MIXTURES

Nichole R. O'Neill[1]

ABSTRACT

Composted sewage sludge infested with *Rhizoctonia solani* was applied as a topdressing or added to soil and seeded with several grasses. Compost applied as a topdressing decreased Rhizoctonia brown patch of tall fescue by 87% at low inoculum levels (0.5%) and by 24% at higher inoculum levels (2.0%). Post-emergence damping off of seedlings grown in compost-amended soil infested with *R. solani* was significantly reduced when small propagules (.5 mm diameter) served as inoculum. Soil amendments of 10% or more compost reduced pre-emergence damping off by *R. solani* to control levels of 86 to 96% germination. Composted sewage sludge, when used as a topdressing or soil amendment, may be useful in reducing the severity of turf disases caused by *R. solani*.

Keywords: Sod production, small farms, turfgrasses, turfgrass diseases.

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INTRODUCTION

Composted sewage sludge has great potential for use as a soil amendment or topdressing in turfgrass production both to enhance the physical condition of the soil and to provide additional nutrients (2). Many small farms are turning to sod production, and there are several turfgrass diseases that cause an economic loss to growers. The use of compost may increase or decrease some of these diseases. Composted sewage sludge has been shown to reduce or increase the severity of several diseases caused by soilborne pathogens (1). Brown patch, caused by *Rhizoctona solani* Kuhn, is one of the most serious diseases on commercial sod farms. Other diseases which may occur include Fusarium blight, rust, and dollar spot. These diseases are very expensive and difficult to control using current disease control practices. Observations in field plots during 1980-1981 indicated that the severity of brown patch and Fusarium blight may be partially suppressed in field plots amended with compost. We investigated the effect of compost on pre- and post-emergence damping off and on brown patch severity using soil and compost mixtures infested with various inoculum levels of *R. solani* (anastomosis group 1).

Suppression of *R. solani* by compost applied as a topdressing

The effect of compost applied as a topdressing on brown patch disease severity of tall fescue was investigated in the greehouse. Sterilized and non-sterilized soil or compost, and a mixture (1:1,V:V) soil and compost, were combined with four rates of *R. solani* inoculum prepared by incubating the fungus on a mixture of sterile, moist bran and tall fescue seed (1:1,V:V). Each topdressing and inoculum combination was distributed over 10-week-old tall fescue plants and incubated three days in a moist chamber at 25 C. Plants were rated for disease severity and fresh weights taken of surviving green tissue.

Compost significantly reduced disease severity as compared with soil or the soil-compost mixture (Table 1). Disease suppression occurred whether or not the soil or compost was sterilized to remove the possible effects of other micro-organisms. The reduction in disease severity was most apparent at the lowest inoculum level used, 0.5%, although a significant reduction in disease occurred even at 2% inoculum.

Tall fescue seedlings grew equally well in pots topdressed with sterilized or non-sterilized compost but produced slightly more tissue when treated with compost compared with soil. This effect is probably due to a higher nitrogen level in the compost. Fresh weights of tall fescue were significantly increased in pots topdressed with compost and inoculum as compared with soil and inoculum treatments. As measured by fresh weight of surviving green tissue, suppression of brown patch occurred equally well at inoculum levels ranging from 0.5 to 2.0%. Results were inconclusive when these experiments were repeated using *Sclerotinia homoeocarpa*, the pathogen causing dollar spot.

Effect of compost on pre-emergence damping-off of tall fescue

Tall fescue seeds were planted in soil amended with 0, 10, 20, and 40% compost and 1% *R. solani* inoculum. The number of germinated seeds was counted after two weeks. Percent germination was significantly higher in soil amended with compost. The germination rate was 60% in inoculated, non-amended soil. Amendments of 10% or more compost reduced significantly pre-emergence damping off to uninoculated control levels (86 to 96% germination).

Effect of compost on post-emergence damping-off

Tall fescue, red fescue, perennial ryegrass, and bluegrass were grown for eight weeks in flats containing soil amended with compost (20%) and *R. solani* inoculum (0.1, 0.5, 1.0, and 2.0%). Flats were exposed to high humidity and temperature (26 C) to induce disease, and were evaluated after two days for disease severity and survival. All seedlings were blighted, and no suppression of postemergence damping off was observed for any of the grasses.

R. solani survives naturally in the field as sclerotia or in infected organic debris. To determine whether a suppressive effect depends on inoculum composition, the effect of compost on survival and infectivity of *R. solani* was evaluated for four propagule fractions.

Inoculum was cultured on a tall fescue:bran (1:1) mixture, air dried, and separated into the following fractions: 0.5 and 1.0 mm diameter propagules without sclerotia, sclerotia greater than 1 mm diameter, and a mixture of 1 mm propagules and sclerotia. These fractions were incorporated at the rate of 1% into sterilized soil amended with 20% compost. Tall fescue was seeded into the soil and evaluated for post emergence damping off after eight weeks.

The effect of soil amended with compost on post-emergence damping-off depended on the form and size of *R. solani* propagules. Survival of tall fescue seedlings in compost-amended soil containing propagules of *R. solani* of .5 mm or less in diameter was very high (90%). When inoculum of 1 mm diameter or more was used, survival was only 66%. No suppressive effect occurred when sclerotia plus organic propagules served as inoculum. Viable propagules of *R. solani* in soil/compost mixtures were estimated after four days by baiting the fungus using a sterile but seed assay. The number of propagules of *R. solani* baited out on seed was similar for both .5 mm and 1.0 mm particles.

Composted sewage sludge, when used as a soil amendment or as a topdressing in turfgrass production, may suppress disease caused by *R. solani*. Under greenhouse conditions, pre- and

Table 1.—Suppression of brown patch of tall fescue by composted sewage sludge applied as a topdressing

	Disease rating[*]			
	Inoculum concentration (%)			
Topdressing treatment	0.0	0.5	1.0	2.0
Field soil	0.0 b/b[**]	8.8 a/a	9.0 a/a	9/0 a/a
Compost	0.0 b/c	2.0 c/b	5.8 b/a	6.8 b/a
Sterilized soil	0.0 b/b	9.0 a/a	9.0 a/a	9.0 a/a
Sterilized compost	0.0 b/c	3.3 b/b	6.2 b/a	5.7 c/a
Soil and compost 1:1	0.0 b/b	8.7 a/a	9.0 a/a	8.7 a/a

[*] 0-9, 0 = no disease

[**] b/b - First letter indicates effect of topdressing at one inoculum concentration; figures followed by the same letter in a column are not significantly different (DMRT $\leq$ 0.05). Second letter indicates effect of inoculum concentration with one topdressing; figures followed by the same letter in a row are not significantly different (DMRT $\leq$ 0.05).

post-emergence damping off of tall fescue seedlings was reduced and disease suppression was observed when compost was infested with *R. solani* and distributed over tall fescue seedlings as a topdressing. The suppressive effect of soil amended with compost on post emergence damping-off depended on the composition of inoculum. A reduction in post-emergence damping off was observed when small propagules (.5 mm) served as inoculum but not when larger propagules or sclerotia were used.

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THE NEW ENGLAND SMALL FARMER PROJECT

Maarten van de Kamp [1]

Pat Lewis Sackrey [2]

ABSTRACT

The New England Small Farmer Project (NESFP) has been working since the spring of 1979 to strengthen the economic position of small-scale commercial producers in the six state region. As a partnership effort between the New England Small Farm Institute, Inc. and the Massachusetts Cooperative Extension Service, the NESFP has made important progress in linking small farmers' concerns with specific programs of action. Field organizers in each state have helped to: identify production, management and marketing needs; locate and provide relevant technical information and services; and to plan workshops and conferences. The Massachusetts Cooperative Extension Service is developing a Small Farm Management Assistance Program that is being implemented in one county of each of the New England states. The Extension Service recognizes the significant contributions of the NESFP in identifying issues and giving impetus to these new directions.

Keywords: Economic development, extension service farm lands, management, marketing, New England, production, rural community, small farmer organizations, small farms, small scale agriculture

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The New England Small Farmer Project (NESFP) was established in the spring of 1979 as a regional effort to provide assistance to small-scale farmers throughout the six state area. Impetus for the project came from the recommendations summarized by participants of the Northeast Small Farms conference held at Poland Springs, Maine in November 1978. In partnership with the Massachusetts Cooperative Extension Service and the New England Small Farm Institute, Inc. (a non-profit educational organization in Belchertown, Massachusetts) the New England Small Farmer Project has developed a program of information sharing and technical assistance. Financial support for the NESFP has come from the Community Services Administration, Action and USDA.

Background of the Small Farmer Project

The NESFP is set against a backdrop of alarming statistics about the decline of regional agriculture during the past three decades. In this period New England has lost 80% of its farmland. Simultaneously, the region has become increasingly dependent upon a highly centralized food distribution system that imports 85% of our food. As small farms have decreased in number, services and businesses supporting farm activity have also declined. This erosion of the agricultural base of rural communities has abetted economic decline in many rural areas.

Various economic, social and historical trends have contributed to the present situation. Many small scale farmers feel ignored by traditional providers of educational, technical and financial assistance.

Historically, small scale agriculture has been the traditional pattern of farming in the region. Rugged topography precludes the establishment of large farms that characterize much of contemporary agriculture.

The NESFP has taken the view that progress to change these long term trends can be best accomplished by working with small farmers for their own self-improvement.

Implementation of the Small Farmer Project

The Project, the first grass-roots project for small farmers in the region, began with the placement of a VISTA organizer in each of the six New England states. The VISTAs, small farmers themselves, are assisting other farmers in their states to improve conditions for agriculture. Small farmers are being helped to form a voice and achieve a sense of identity as they become a recognizable part of the food system. Beginning with delegates from the Poland Springs conference, the VISTA organizers have brought small farmers into working groups. These groups decide how they can best effect change and thus give the Project its direction. The Project's central staff receives guidance from a low-income farmer delegate advisory committee and during farm visits and farmer conferences.

Based on the recommendations of the small farmer advisory committee, the Project identified three major needs:

First; technical assistance appropriate to small-scale farmers in production, marketing and business management is needed in order to effectively deliver applicable, useful advice; there is a need to provide training for farmers and USDA field personnel in management and technology appropriate to small-scale farming.

Second; there is a need to increase the role of farmers in rural community economic development. Small farm families need assistance to identify opportunities and gain the skills necessary to help themselves economically by vertically and horizontally integrating within the food system. Cooperatives for marketing, farmer-owned food processing and storage facilities and on-farm enterprises (e.g. cheese making) can add value to their own raw products and labor. These enterprises are critically needed by small operators in particular who have little or no access to other options for improving their farm incomes.

Third; the small farmers have expressed the need for more "citizens' training." Information on the legislative process is necessary for the small farmers to make their voices effective.

Goals and Objectives

The long term goal of the Project is for New England to have a thriving population of small-scale farmers who contribute significantly to the regional food supply. They will be seen, and will identify themselves, as a group with power to hold agencies and decision makers accountable for their decisions.

Objectives of the Project include:

- to increase number of new members in small farmer organizations;
- to increase participation of farmers on ASCS, FmHA, and Extension county committees;
- to insure visibility of farmer membership in Rural Development Committees and related small farm subcommittees;
- to train farmers in workshops and conferences; farmers will evaluate those training experiences;
- to expand the role and responsibilities of the small farmer advisory board;
- to increase farmer support and awareness of state legislative activities regarding agriculture.
- to increase state agricultural development efforts;
- to increase responsiveness of Extension and other USDA agencies;
- to increase contacts of small-scale farmers with Extension, FmHA, and other USDA personnel.

The Project has pursued these objectives by:

- continuing to form linkages between farmers and key agency personnel and decision makers;
- identifying opportunities with and for farmers to strengthen and expand their economic position within the food system;
- making available training in credit issues, production, management, and establishment of small-scale community and individual economic enterprises that will make the farmers' position in the local or regional food system more secure.

The NESFP has made important progress with numerous specific accomplishments. The following list summarizes some of the more important efforts of the past two and a half years.

1) According to their own estimates, the VISTA fieldworkers directly and indirectly have worked with approximately 2000 farmers. Numbers, however, are not the only measure of our accomplishments. The VISTA worker in Northern Maine who helped 5 vegetable producers to start a farmers' market is considered as great a success as the Southern Maine VISTA worker whose Produce Marketing Conference was attended by 160 farmers.

2) VISTA fieldworkers have helped numerous farmers, including beginning farmers, explore sources of credit and they acted as liasons between credit officers and farmers. A Small Farm Credit Tour has been arranged by the VISTA worker in Southern Vermont. Loan officers from FmHA and Farm Credit System will be taken on tours of four small farms. The goal is to present them with information needed to judge the profitability of non-dairy enterprises. The tour could have a great impact on access to credit for small farmers, and will serve as a model for tours in other regions. NESFP published a booklet entitled "Credit Facts for Small Farmers" summarizing major aspects of acquiring credit. Its popular reception has resulted in a second printing of 2000 copies.

3) Approximately 500 farmers have had the chance to offer input on legislation and regulations affecting them, with VISTA workers providing education and referral. Bills which have been adopted include: Institutional Purchase Bill (Vermont), and Farmland Preservation (Rhode Island). The budget of a Maine Cooperative Extension Service program was spared proposed reductions with the help of 12 farmers who were invited to offer their input.

4) VISTA fieldworkers have provided technical assistance to farmers' markets and have initiated 6 new such markets (in Maine, Connecticut, Vermont, and New Hampshire).

5) Organizations serving farmers consult with VISTA fieldworkers on a regular basis. For instance, the New Hampshire Small Farms Task Force enlisted the help of NESFP in designing a state action plan. A VISTA worker also serves on the steering committee for the Maine Sheep Development Plan. In Vermont, the Small Farm Sub-committee in Windham County enlisted a VISTA worker to conduct a survey of 42 small farmers to help assess their needs.

6) NESFP sponsored, co-sponsored, assisted, and/or attended numerous workshops, conferences, and meetings. NESFP sponsored a Livestock Marketing Conference in Maine, and co-sponsored the Vermont Federation of Farmers' Markets Conference. The Rhode Island VISTA worker helped Cooperative Extension Service plan small farms conferences. The Southern Vermont VISTA worker linked a group of swine producers who might otherwise not have met. They have developed some concrete marketing strategies which should yield economic benefits.

Cooperative Extension Service Small Farm Programs

During its first two years, the Small Farmer Project was based at the University of Massachusetts. This situation engendered mutual benefits for both the Small Farmer Project and the Cooperative Extension Rural Development specialists supporting this effort. The NESFP was provided with office space and fundamental services as well as the continuing encouragement and assistance from Extension personnel.

The Massachusetts Cooperative Extension Service has simultaneously made a continuing commitment to the development of a long term Small Farms Program by coordinating a Small Farm Management Assistance Program that is being implemented in one county of each of the six New England states. This program is designed to provide help for small scale commercial farm families having net family incomes below the median non-metropolitan level. This effort is focussed specifically on improving economic conditions for participating farm families.

To promote the goal of attaining greater self sufficiency for participating families, the program employs part-time Management Assistants who are members of the communities they serve. Supported by county Extension personnel, the Management Assistants have identified eligible farmers who have agreed to participate. Through continuing individual consultations, the Management Assistants are helping these farmers to assess their current situations and to define specific goals for improving overall management, production and marketing.

The Small Farm Management Assistance Program has had a successful start-up period. Assistants have been trained and each has contacted 30 to 40 farmers and enrolled an average of 14 as participants. The intensive nature of farm visits combined with applied knowledge has caused participants to speak highly of this program. County Extension personnel recognize the Assistants as an important component in expanding the effectiveness of their own efforts.

The Small Farm Program of the Massachusetts Cooperative Extension service also supports a Resource Center that responds to informational needs of farmers as well as helping University and agency people working with small-scale commercial farms. The Resource Center has developed an extensive collection of information based initially on the work of NESFP and more recently expanded to work with the Small Farm Management Assistance Program as well as County Extension Personnel.

This current Small Farms Program of the Massachusetts Cooperative Extension Service is seen as the beginning of a long term commitment to acknowledge the role of small farms in the economies of rural communities. The Extension Service recognizes the significant contributions of the New England Small Farmer Project in identifying issues and giving impetus to these new directions.

MAINTAINING MARKET QUALITY OF FRUITS AND VEGETABLES

Harold E. Moline [1]
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ABSTRACT

Quality is a major factor in the marketing of fresh produce. Maintaining high quality requires knowledge of postharvest factors that can reduce fresh fruit and vegetable quality. Practices are discussed that can help the small farmer maintain the highest postharvest quality at roadside stands and other markets.

Keywords: Bacterial soft rot, chilling injury, intermittent warming, peaches, peppers, small farms, strawberries.

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Preserving the harvested quality of fresh produce is of great importance to growers as well as consumers. Today many family farms are electing to market some or all of their produce at roadside stands and farmers markets. By doing so the grower can increase his share of the market value of fruits and vegetables; however, he must be aware of quality factors that influence perspective buyers if he expects to attract prospective customers. Large volume vendors may have refrigerated storage to maintain the market life of produce while others must rely on rapid turnover of perishable produce to minimize losses. Growers at both extremes can benefit from some of the following procedures to reduce decay losses and maintain the highest quality marketable produce.

Peaches are a high value seasonal crop and a favorite of roadside stands and farmers markets; however, brown rot and other postharvest decays can severely limit their market life. Hot water dips have been shown to be a nonchemical means of controlling decay. Hot water dips of 2-1/2 minutes at temperatures between 49 and 52°C proved effective in controlling brown rot of fresh market peaches (Smith, 1962).

Refrigeration during holding or transit is the most common method of controlling decay and delaying ripening of produce. Many tropical and subtropical fruits and vegetables are severely damaged by chilling injury if held at temperatures below 7-13°C for extended periods (Lyons, 1973). Intermittent warming can be an effective means of reducing or preventing chilling injury. Anderson and Penney (1975) found that peaches could be stored for 6 weeks or more at 0°C if they were warmed for 2 days at 18° after 3 weeks. Other types of produce that respond favorably to intermittent warming include tomatoes, cucumbers, peppers, eggplants and summer squash with time and temperature varying with each commodity.

Bell peppers are another popular cash crop that is extremely susceptible to postharvest decay. Bacterial soft rot is the major cause of losses of Bell peppers. Many growers wash their peppers after harvest to remove field dirt. Decay causing bacterial are spread in the wash water and any break in the skin is a potential infection site. The addition of 250 parts per million (ppm) chlorine to wash water is an effective means of reducing this decay. Studies showed that decay could be reduced from 15% to 5% with the addition of 250 ppm chlorine to the wash water. This control measure was not effective, however, if peppers were harvested within 48 hrs of a heavy rain that splashed dirt and bacteria onto fruit.

Strawberries are becoming one of the highest return cash crops for many family farms. They are also one of the most perishable fresh market fruits. Decay and shriveling can quickly reduce their value. A study was conducted to evaluate the effect of packaging and temperature on weight loss and decay of harvested fruit. Three different strawberry cultivars were harvested from a local commercial field. The fruit were placed in one pint plastic containers and were either covered with a polyethylene film wrap or left open. Samples of each cultivar, covered and uncovered, were placed under 4 different temperature regimes (10, 15.6, 21.1, and 26.7°C). After 3 days in storage at the various temperatures, weight loss was determined and the berries rated for loss due to fungal decay. Average weight loss among the 3 cultivars was reduced by 22% in berries which were covered and stored at 10°C when compared to berries which were stored at 26.7°C and not covered. Loss due to fungal decay was decreased by about 35% in berries stored at 10°C when compared to those which were stored at 26.7°C. When comparing disease loss between covered and uncovered berries, it was found to be similar at 10°C, but as temperatures increased, covered berries showed somewhat more disease than those left uncovered. The results of these initial experiments indicate that reducing the short-term storage temperature of strawberries combined with a suitable covering significantly reduces weight loss (dehydration) and loss due to fungal decay.

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RESPONDING TO THE TECHNOLOGICAL CHALLENGES OF SMALL SCALE AGRICULTURE

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ABSTRACT

Text of speech presented at the banquet of the Beltsville Agricultural Research Center Special Symposium " Research for Small Farms" November 17, 1981, at the Continuing Education Center, University of Maryland, College Park, Maryland.

Keywords: Agriculture, computer data base, computers, cooperative program, Control Data, economics, education, family farm, new technologies, research, research and development, rural areas, small farms, small-scale agriculture, technology, and training.

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Good Evening. It is a special pleasure for me to participate in this symposium. Because of my lifetime interest in agriculture, I am always eager for discussions on the subject, but the added dimension of small scale makes it a special event.

Knowing that most if not all of those in attendance are believers in small scale agriculture, I don't need to spend much time reviewing its merits. Instead, my remarks will focus primarily on what is being done by Control Data -- in cooperation with many other organizations -- to improve small scale farming. I hasten to add that broad-based cooperation is essential, indeed mandatory, to achieve that objective, because the resources required are far beyond those of a single organization or government alone.

In my presentation tonight, I will first describe the underlying rationale of the cooperative program and then review implementation, which essentially has two main parts, one under the aegis of Control Data and the other carried on by a consortium called Rural Venture, Incorporated.

RATIONALE

The rationale is simply that with proper selection and application of existing and emerging technologies, and with adequate ongoing research and development (R&D), small farms and small scale food processing operations can reduce the cost of food, make a significant contribution to food production, do it in more environmentally protective ways, and provide a decent living for the operators. These objectives cannot be accomplished overnight, but there is enough existing technology to get meaningful results in a few years and, with adequate and continuing support, reach significance on a national scale in ten to fifteen years.

Further that Control Data can help achieve these objectives in a number of ways: First, by catalyzing more research and development applicable to small scale agriculture; second, by assembling existing and emerging technologies in a readily accessible computer data base; and, third, by offering high quality, easily available and affordable education and training to small-scale farmers in planning, management and the application of new technologies. In the process, Control Data will eventually earn a reasonable profit from investments in these and related efforts.

At this point, I should mention that I use the words "technology," "how-to" and "knowledge" interchangeably. I believe "how-to" communicates best, but it is at times a bit awkward to use.

SUPPORTING EVIDENCE

The perception that small-scale farming has great potential is not the prevailing view. Most experts agree that social benefits would be derived by improving the lot of the small farmer, but few experts believe smaller farm units would produce attractive economic benefits or become significant contributors to the food chain.

Although not yet widely perceived, there is a growing body of evidence that the so-called experts are wrong; and better solutions to many of the basic problems plaguing the nation's food chain can be realized by means of the small family farm rather than through large, capital-intensive, fossil fuel-based operations.

Too often, the efficiencies of large scale fossil-fuel, capital-intensive agriculture have been accomplished without adequate regard to the loss of jobs, damage to the environment, the effect on human health, and other factors, including the depletion of future production capacity by utilizing practices equivalent to mining the soil. Practically, then, the "efficiencies" have been achieved at added cost to society, and are really subsidies to big agribusinesses. Often, the government and universities have been the vehicles providing such subsidies to large scale agriculture. One good example is the channelling of most government agriculture R&D funds into programs which benefit large-number but not small-scale production. There is no broad indictment implied of the community of large farmers; rather, the emphasis is on the need for constructive changes in large-scale practices and on the importance of the smaller operation.

The USDA this summer released a report entitled Economies of Size in U.S. Field Crop Farming, which concludes that "farms reach efficiency at small or modest sizes" ... and that "many commercial farms now exceed the size necessary to achieve all available cost efficiencies." The study further states that "since medium-size commercial farms with gross incomes from $41,000 to $76,000 achieve most technical cost efficiencies, society benefits little in terms of lower real food costs from further increases in farm size."

Again, the main theme of our rationale is that available technology (if properly packaged and disseminated) and future research (if vigorously and intelligently pursued) will lead to profitable and viable small family farm operations without benefit of subsidies. The very existence of substantial numbers of currently available appropriate technologies holds the promise of many more being developed.

Further evidence can be found in past experience, current practices, experiments, and emerging technologies relevant to small-scale operations. Although I am among believers tonight, in our society it is still customary to preach to the converted once a week, so I will cite a few examples.

One of the most significant has been the development of small farm models which have demonstrated substantial production gains by integration of limited acreage high-value crops and small-scale animal agriculture, notably sheep and hogs. Corresponding models are in the process of being developed for dairy goats and beef cattle. I will provide additional information about the sheep model later.

Additional and alarming evidence is found in the area of soil conservation. After more than 40 years of a national soil conservation program, only about 25% of U.S. farmland is managed with appropriate soil erosion practices. However, with intercropping and minimum tillage practices -- which are most feasible in small-scale operations -- our increasingly dangerous problem of soil run-off can be substantially lessened (estimated reductions of 50% by the year 2000) and total yield increased. In addition to reducing erosion, selected intercropping of from two to eight plant varieties has increased some small farm incomes in the eastern U.S. by 50%.

I should also note at this point that the benefits of more intensive agriculture are clearly visible in countries like Denmark, The Netherlands, Korea and Japan -- all of which have a preponderance of small farms -- where higher yields per acre are being obtained for many crops.

Other evidence testifying to the viability of small-scale agriculture can be found in solar technologies, irrigation methods, wind generation, small-scale machinery and controlled environment crop growing.

A number of solar technologies, either in-hand or emerging, make small-scale grain drying and storage more efficient than present fossil fuel-intensive methods. Other solar applications are providing sources of power for irrigation and adequate heating for animal buildings, even in northern climates.

By the mid-1980's, the nation will face a major water crisis. Water tables are declining rapidly in many areas, drying wells and dramatically raising the cost of pumping water. In this context, it is encouraging to learn that tests of a small scale sprinkler irrigation system currently nearing completion indicate a 15% savings in energy and as much as a 20% savings in water.

Wind generators in the range of 10 - 25 kw are also under development, will soon be cost-effective, and represent a significant step toward farm energy self-sufficiency.

Machinery for small scale farming is becoming more readily available. Included in this category are tractors, tillage implements, harvesters and more efficient human-propelled tools.

And, not to be overlooked, small-scale controlled environment agriculture is becoming viable. By controlling the principal environmental factors which effect plant life -- such as light, heat, atmosphere, nutrients, and so on -- much higher production can be obtained per unit of space.

Perhaps the most convincing evidence, however, is what I saw more than fifty years ago as a boy growing up on a farm in Nebraska. At that time, most of the farms were around 160 acres in size and raised both crops and livestock. Each farm had a high degree of self-sufficiency because organic fertilizers and horsepower were used. The net result was that farmers and nearby small towns prospered. But the degree of self-sufficiency decreased dramatically with the introduction of fossil-fuel, capital-intensive and less integrated methods. Profitability declined along with self-sufficiency because a substantial part of the proceeds was shared with agribusiness. That, of course, triggered consolidation into larger farms, which set off an exodus of people from the land and struck the death knell for many small towns in rural America. I need not go on with the litany of woe. It is well known.

Many more small-scale technologies, currently available or under development, could be mentioned. Suffice it to say, the examples reviewed demonstrate the point that sufficient "know-how" is available to significantly enhance the productivity of small family farms and small scale food processors. With further focused R&D, increased viability over a wider range of conditions can be even more firmly established.

IMPLEMENTATION METHODS

That completes the description of the rationale. Control Data's methods and tools to assist in implementing the approach include: The assembly of a computer data base of appropriate technologies; preparation of the necessary education and training materials; catalyzation of further research and development relative to small scale technologies; establishment of agriculture and business service centers to distribute technology, education and training and other services to people operating small farms and related small businesses; and, of course, participation in Rural Venture.

Computer Data Base

The computer data base, which we call AGTECH, includes practical, how-to information about crop and livestock production; alternate energy sources such as wind, solar and biomass; methods for achieving more efficient use of water in irrigation; and so on. Technologies have been obtained from many sources, the most significant from Brigham Young University, which for many years has been an ardent developer and practitioner of small plot agriculture.

Education and Training

Education and training required to efficiently teach farmers how to use the technologies is primarily accomplished through the use of the PLATO computer-based education system. It is a part of Control Data's largest program, which is addressing the worldwide need for better, more available and less costly education. The only practical way to make significant progress in addressing this massive and urgent need is through the use of technology such as television, audio/video tapes, and telephone and satellite transmission coordinated in a network learning system with computer-based education.

For 19 years Control Data has been engaged in developing such a system, called PLATO computer-based education. The effort included scores of cooperative projects with the government, universities, large companies, small organizations and individuals. PLATO lessons are stored in a computer and are accessed through television-like terminals operated by students at their own pace using typewriter-like keyboards and touching the terminal screen. Lesson information is displayed in the form of numbers, text, drawings and animated graphics. There is continuous interaction — a give and take — on a personal, one-to-one basis, supplemented with video recordings and texts, thereby creating an effective learning experience which cannot be practically achieved by any other method on a broad basis.

As a result of this substantial effort, a wide range of high quality PLATO instruction is available, including courses for business, industry and agriculture; academic and vocational courses for high school and college students, and both remedial and continuing education courses for out-of-school adults. Especially important to the advancement of small scale agriculture are the basic skills and high school skills curricula, because many persons living in poverty-stricken rural areas, especially in developing countries, are functionally illiterate.

Basic Skills

Control Data has been co-developing the basic skills curriculum for many years, These lessons help those who are educationally disadvantaged to advance from third-grade to eighth-grade equivalency in reading, language and math. And this advancement can take place in much less time than that required for traditional teaching methods. Lesson materials for 0-3 grades are currently being designed.

Impressive results are being obtained. For example, in the City of Baltimore, 24 functionally illiterate adults advanced almost one full grade level in reading after only 22 hours of instruction -- 20 of them on PLATO. Another group of 200 high school students in the State of Florida advanced an average of one grade level after only 14 hours of computer terminal time -- and these were failing students threatened with the prospect of not graduating because of the state's minimum competency requirements.

High School Skills

The PLATO-based high school skills curriculum is called the General Education Learning System, which consists of courses in reading, mathematics, writing, science and social studies. The five subjects correspond to the five parts of the general education diploma (GED) examination, the main criterion of adequate skill levels in this country.

Finally, with respect to PLATO, it is important to emphasize that the computer is critical if small scale agriculture is to succeed in reaching its goals. Without the computer, the needed technologies could not be efficiently assembled and distributed -- and providing the required education and training would be too costly.

Research and Development

To help catalyze needed research and development, Control Data for a number of years has been making significant grants to universities and research institutes to help support cooperative development of small-scale technologies. In addition -- acting on the belief that demonstrating success would encourage research and development by others -- Control Data has provided direct assistance in the incorporation of small-scale technologies in farm projects. A partial listing of the technologies being used in some current projects is shown on the slide. The technologies used in these efforts are, of course, listed in the AGTECH computer base.

In addition to the R&D grants to universities and research institutes, Control Data is investing in the development of small scale controlled environment agriculture and small scale food processing — and in small companies developing products needed by small farmers. Let me briefly review the nature of the controlled environment research and then describe just one of the products being developed by a small company.

Controlled Environment Agriculture (CEA)

The development of controlled environment agriculture has important implications for virtually all parts of the world, and Control Data is making a major investment to develop different types of small scale techniques that are highly efficient; provide faster growth, higher yields, and higher quality; and are suitable for use in different geographic locations. The technology is being franchised for operation by others.

One type of controlled environment agriculture utilizes waste heat from many different sources and is shown here installed on the roof of a building -- it uses heat from large computers on the floor below. Both natural and artificial lighting are used, and a small computer controls temperature, carbon dioxide and so on. Another type, which we call multiponics, is totally enclosed and utilizes only artificial light. Here is an internal view of lettuce being grown — and the next slide shows a building under construction in the inner city of St. Paul by the first small business franchisee. Operation here will commence early in January.

Wind Power

The product to be mentioned is a 10 kw wind generator developed and marketed by the Jacobs Electric Company. This a highly reliable unit which can be used anywhere in the world. Fifteen and 25 kw models are under development.

AG Centers

The next part of the implementation strategy to describe is what we call agriculture and business services centers. In addition to providing access to the agricultural data base and delivering the PLATO courses, the centers also provide assistance in preparation of farm business plans and help in analyzing actual financial and production results. For persons in small business, a wide range of high quality courses is also available: how to establish and manage a small business, accounting, selling, purchasing, government regulations and many other subjects important to successfully operating a small business. A number of courses have been tailored to the needs of women entrepreneurs.

An expanded version of the agriculture and business services center enables small businesses to physically occupy office, laboratory and manufacturing space at the center and to share other facilities and services such as a library, model shop, drafting, accounting, purchasing and computer services. Economies of scale make it possible to provide occupants of the center with needed facilities and services of much higher quality for considerably lower cost than any of them would be capable of acquiring alone. Benefits are also obtained from the enhanced environment for peer interchange.

Every rural community needs an AG center of some type. Within the next 18 months or so, as the agriculture technology data base grows and more PLATO courses are completed, AG centers operated under license agreements will become attractive small business opportunities. The smallest version can be started with an initial investment of less than $15,000, which is sufficient for the purchase of a small computer, selected education and training course materials, and access to the agriculture technology data base via telephone.

RURAL VENTURE

In order to greatly expand the scale and range of small scale agricultural activities addressed, Control Data has joined with other organizations to form Rural Venture's, Inc. The participants in this for-profit consortium include corporations, farm cooperatives, a foundation, church organizations and individuals. A complete listing of the stockholders appears on the slide.

Rural Venture engages in rural development. Its main thrust is to increase the productivity and profitability of small farms; to assist in the start-up and profitable growth of small business in rural communities; to help achieve significant advances in education and training, health care, housing, and communications; and, in the process, to create jobs and vastly improve the economic base of depressed rural areas.

PROGRESS

Next, I will review the progress being made in building the AG technology base and in Rural Venture's business. The agriculture technology base has been growing rapidly and there are now some 11,000 listings. Many are organized by farm enterprise. As an example, one listing describes technology for sheep production and management — and a corresponding practical and intensive PLATO course teaches its applications. The course, entitled "Sheep Production and Management," was developed cooperatively by the Winrock International Livestock Research and Training Center, The Rockefeller Brothers Fund, The Pipestone Minnesota Area Vocational Technical Institute, and Control Data. It provides the basic knowledge required to efficiently run a sheep operation. We have had many favorable reports about the effectiveness of the Sheep Production and Management course. For example, I recently received a letter from a freelance writer who had just completed the course. She wrote: "I am tremendously impressed by the course as a whole. An enormous amount of information has been packaged in an easily digestible and absorbable form. I have enjoyed myself very much - and learned a great deal. However, I have a suggestion to offer. The lead sentence in module 3 — Pre-Lambing Management — needs to be changed. The sentence reads, "Once you and your sheep have successfully completed the breeding season, your ewes should all be pregnant." To avoid the laughter and the tired farmer/sheep jokes, the words 'you and' should be deleted."

Another entry in the data base similar to the sheep production reference describes swine production. Within the next ten months, goat and dairy production will be completed, with cattle to follow about a year later.

Education and training courses on many subjects are available, and more are in process of preparation. A partial listing is shown on the slide.

Pine City

Rural Venture is also making excellent progress. The first project managed by the organization is headquartered at Pine City, Minnesota. The project, financed by Control Data, started in the spring of 1979 with an objective of assisting a group of 18 small farmers. Today it is part of a larger six-county Rural Venture project in East-Central Minnesota.

Participants came to the Pine City program with farming experience ranging from none to ten years; many of them had failed to achieve more than limited success before the program started.

The farms involved vary between five and 140 acres in size; the land is marginal and is located in an area considered by the government to be economically depressed. In addition to helping prepare farm business plans and consulting on the operation of the farms, Rural Venture is also drawing upon Control Data training services tailored to the needs of each individual.

At the beginning of the program, all participants were part-time farmers. By the spring of 1980, several had progressed enough to quit their off-farm jobs and support themselves as full-time farmers.

Princeton

A second Control Data financed project in Princeton, Minnesota, involves a group of 15 beginning farmers. It began in 1980 and is now also part of Rural Ventures's area-wide program in Minnesota.

The main objective in Princeton is to establish successful operations which can be widely replicated. The farms are 80 to 140 acres in size and the land somewhat better than in the Pine City Project. Also, unlike the Pine City participants, most of the Princeton farmers are new to the land.

Construction of solar-tempered, earth-sheltered homes and a variety of farm building is well underway. About a third are completed, and the first crop and livestock operations were launched last spring. Rural Venture managers are living in the Princeton area and working with the farmers in every phase of the program.

Alaska

Two other Rural Venture projects are located in Northwest Alaska near the villages of Ambler and Selawik, both within the Arctic Circle. Ambler has 200 inhabitants; Selawik, 600.

The objective of the Ambler Project, which started three years ago, is to establish an integrated small farm operation combining vegetable and small grain growing with livestock production. Thirty-five acres of tundra have been cleared thus far. Wheat, barley and a variety of vegetables -- including cabbage and potatoes -- have been successfully grown this year. The farm is operated by an enterprising Eskimo couple.

The objective of the project at Selawik is similar to the one at Ambler. The farm is presently operated by the village as a community effort, but will eventually be divided among a number of individuals.

New England

The focus of another Rural Venture contract, with the New England Regional Development Commission, is improved and expanded sheep production in a six-state area. The application of the latest technologies in sheep production will improve net income for both small farmers and related businesses. During the first year of the program, 25 farmers along the Connecticut River Valley are participating. Plans are being formulated to increase that number to 60.

Virginia

Recently, Rural Venture also completed a nine-month contract with the Virginia State Private Industry Council to develop a plan by which private jobs would be created in a ten-county area during the next five years. The three primary components are agricultural development, small business development, and employment preparation training. The major emphasis is on agriculture; specifically, diversified small-scale operations. The objective is to provide services to several hundred small-scale farmers over five years, such that they can derive a decent income from full-time farming.

Jamaica

The last Rural Venture project I will mention is being established in Jamaica. With the election of a new government in October of 1980, there has been a turning away from the socialism of the previous regime to an emphasis on private enterprise for meeting the country's needs. The new Prime Minister, Edward Seaga, was the first foreign Chief of State to visit President Reagan. One outcome of the meeting was the establishment of the U.S. Business Committee on Jamaica to help improve economic performance, which had seriously deteriorated under the previous government. For example, the unemployment rate exceeded 30%.

There is a consensus within the committee and in Jamaica that agriculture is a primary area for aggressive development. A plan is being prepared to assist in the achievement of this goal -- and the plan is reckoning with the large numbers of small and medium scale farms in Jamaica -- some 150,000. While the plan is not yet complete, it is evident that there is a consensus for proceeding with a project to vastly improve small scale agriculture. A Rural Venture consortium is being formed in Jamaica which will work with Rural Venture here in the U.S. in applying small scale farm technology to Jamaica's needs. Such broad-based cooperation among Jamaica and U.S. organizations is both a powerful and equitable approach.

ECONOMIC AND HUMAN IMPLICATIONS

Even though achievements in advancing small scale farming by Control Data, Rural Venture and other organizations to date are modest compared to what can be done, they do demonstrate clearly the great potential of small scale operations. However, progress must be accelerated to meet a number of major and pressing economic and business needs in a more timely manner -- both here and overseas, especially in developing countries. Let me spend a few minutes reviewing some of those needs and the relevance of small scale agriculture, first by looking broadly at some of the realities of U.S. agriculture, then by considering rural poverty and the "back to the countryside" movement. After that, I will focus on developing countries.

U.S. Agriculture

Large-scale U.S. agriculture is often extolled by such statistics as:

> During 1980, one farm worker produced enough food for himself and some 60 other people.
>
> During the seventies, one-third of total agriculture production was exported. This ratio of export to production has never been achieved by any other country.

Indeed, these statistics touting the productivity of American agriculture are impressive, but they are only part of the current picture. A broader look shows:

> U.S. agriculture has anemic profitability, even though propped up by government subsidies.
>
> Yields of major food crops have plateaued.
>
> As noted earlier, yield per acre is higher in many countries where small farms are preponderant.
>
> And, as previously mentioned, the adverse consequences of large-scale, fossil-fuel, capital-intensive agriculture with respect to jobs,

damage to the environment, human health and other aspects are rarely factored in.

Leaving aside the matters of profitability and adverse effects for the moment, it is apparent that growth in agricultural production to meeting rising world food demand and to help correct massive U.S. foreign trade deficits will require increased levels of crop yeilds and/or increased amounts of land, energy and water. With the prevailing system of agriculture, neither is likely to happen, at least not during the next 10 to 15 years.

To begin with, expansion in our land resources will not occur to any great extent because of a number of factors. One is urban sprawl, which removes from cultivation one to two million acres per year. And as noted, soil erosion is steadily decreasing the productivity of some of even the best farmland. Utilizing presently uncultivated marginal land has potential, but it can't be fully realized by large scale fossil-fuel intensive methods. The greatest potential for improving productivity of marginal land by small scale agriculture is in the large, arid regions of the Western United States, the uncultivated land of Alaska, and the under-utilized acreages on Indian reservations.

Water is another limited resource. The United States has a finite amount of ground water — in a number of important agricultural areas, it has either been depleted or will be within the next ten years at present rates of consumption. As for energy, its availability and rising cost have also become limiting factors.

With further research, crop yields will no doubt be increased through genetic improvements, greater photosynthetic efficiency, enhancement of nitrogen fixing capabilities and other methods. But the promise of these emerging technologies must be viewed with the reality that it takes at least ten years for a new agricultural technology to move from the research laboratory to the farm.

Considering resource limitations, the time required to get new agricultural technology from the research stage into the field, the need for increased profitability, the adverse effects too often present with large scale agriculture, and, on the positive side, the know-how presently available to significantly enhance the productivity of small family farms, the answer has to be a vast increase in small scale agriculture.

Rural Poverty

Expansion of small-scale agriculture is also needed to better address rural poverty in the United States. Forty percent of our nation's poor live in rural communities, more than a fourth of them in inadequate housing. Health care facilities are also often inadequate, especially in isolated areas. Some of the poorest are found on Indian reservations. Unemployment is a virtually intractable problem in many rural areas because of little or no industry and a scarcity of capital, technical and management resources. Expanding and increasing the efficiency of small scale agriculture can provide the means for creating new jobs both on the farm and off. Recent studies show that for every job created on the farm, two more will be generated in nearby small towns.

Indian reservations can greatly enhance employment and economic advancement for tribal members with small-scale agriculture. In fact, Rural Venture is in the initial stage of developing small-scale agriculture programs with a number of tribes.

Developing Countries

The most urgent need for more efficient small-scale agriculture, however, is in developing countries. There are more than one billion small farmers in the developing world, yet per capita food production is declining in all developing regions except in Asia. Without great improvement in small-scale agriculture, there is little hope for significant economic progress, because the initial progress achieved with the large-scale "green revolution" agriculture of the last half century has slowed sharply in recent years.

The Rural Venture project in Jamaica, described earlier, will be a stepping stone for a broader-based effort in other developing countries. While further research and development with respect to small-scale technology is needed, substantial production gains can be made in developing countries by improving the process for teaching the use of existing technologies. This can be accomplished effectively and economically with computer-based education. Success in Jamaica will accelerate adoption by other countries.

NATIONAL PROGRAM

In order to accelerate the advancement of small scale food production in the U.S., a national program is needed -- based on new legislation and policy changes. Time isn't available to enumerate all of the elements in such a program, so I will only mention a few of the most important.

Policy

One critical change in policy would be some redirection of federal and state research funding to increase efforts devoted to small-scale technology development, particularly with respect to integrated small scale production and energy generation. At the present time, the amount of support for small-scale agricultural research is a very small percentage of the total funding for agricultural research. For example, the last report I saw shows that research at state agricultural experiment stations aimed specifically at small farms represented less than half of one percent of the total for research. Fortunately, substantially more research directly applicable to small-scale farming is being performed overseas.

Legislation

Part of the new legislation needed to improve the environment for small-scale farming also applies to small business. Since I have written and spoken extensively about new legislative initiatives for small business, I won't repeat them at this time. I will only review those pertaining to small farms, which include the following:

1. Increased availability of low cost loan financing for small farms.
2. Tax incentives for owners to sell land to small farmers.
3. Tax credits for investments in agricultural business and technology centers which provide education, training, and technology to small farmers.
4. Establishment of rural enterprise zones for a twelve-year period. The legislation would provide tax incentives and other means to stimulate investment and provide support to help assure successful startup and profitable growth of small farms and small rural-based businesses. Two rural enterprise zone bills are pending in Congress; however, they are too narrowly focused. With an enlarged scope, the rural enterprise zone concept could be very effective.

It is my belief that the costs of such legislative initiatives would prove to be a good investment for taxpayers because they would facilitate job creation. Although limited in extent experience thus far indicates that the one-time cost in government funding per job created by the Rural Venture type of projects mentioned earlier will probably average around $15,000. However, studies show that the average value of a job to our society is around $30,000 each year. Considering that a job in the private sector will exist for ten years or more, there is an enormous return from the one time investment.

A national program stimulating the creation of jobs in rural areas through the expansion of smaller scale agriculture, which is more productive, environmentally protective and resource conserving, is very much in consonance with President Reagan's policies. If the private sector will take the initiative, it is the type of program I believe the administration and state government will support. I have attended meetings with the President to review private sector initiatives, so I am speaking from first-hand experience.

CONCLUSION

On that note, I will start to conclude. Instead of summarizing what I have been saying, I will further emphasize the benefits of vastly increasing private initiatives to advance small-scale farming.

Uppermost in my mind here at home is the need to provide enough career opportunities for our youth, especially those who are disadvantaged. A small farm can provide an attractive option. We know from experience that there are large numbers of young people who would be elated if such an opportunity were available.

At the other end of the spectrum are families on larger farms who are unable to make enough income to continue indefinitely. Unless a more attractive alternative model is available, they are not going to stay in farming. The small-scale model offers an alternative.

In other words, considering demand and progress in establishing feasibility, a huge domestic market is developing for small farm technologies. The U.S. Department of Agriculture, the Agricultural Extension service and universities will be unable to adequately respond to it because of traditional constraints and shrinking budgets. Those in the private sector who are far-sighted will develop, assemble and deliver the technologies and reap attractive profits.

A key element in the process is the AG center described earlier. Next year ten individuals in various parts of the country will be participating with Control Data in the opening of small centers. They will be selected on the basis of a deep personal commitment and willingness to innovate.

After a year of experience in working with these individuals to refine support procedures, the number will be increased to one hundred in 1983. Thereafter, an expansion to some 10,000 centers will occur in about five years.

Some may consider that to be an overly optimistic goal. However, the seriousness of the situation we face calls for goals we must stretch to meet in order to assure maximum progress. America has been the breadbasket of last resort for the world for more than a century. America has provided its citizens with a stable, plentiful and nutritious food supply unparallelled in history: We must take every possible creative step to preserve that legacy.

At the same time, there is the far larger and more critical problem of improving the efficiency of small-scale agriculture in developing countries that must be addressed.

From my own personal experience on the land — and after fifty years of experience embracing a broad range of technology -- I am totally convinced that responding to the technological challenges of small scale agriculture I have outlined tonight is vital to the preservation of our American heritage and to meet the awesome task of greatly improving agricultural production in the developing world.

THE WHITE HOUSE
WASHINGTON

November 17, 1981

I am very happy to extend my greetings to small farm experts, representatives of the United States Department of Agriculture, and guests gathered for this Conference on Small Farms.

Small farms provide a way of life for hundreds of thousands of American families. They enable many of our citizens to live in a rural environment where they prefer to raise their families and stay in touch with this nation's agrarian heritage.

Small farms provide a significant part of our national food supplies and a very significant part of some specialty crops. They help local communities maintain a diversity of food production which could be vital in case of any major disruption of the food distribution system. Small farms give many families who work in town jobs a base which can tide them over in lean times by providing food and shelter. They give people security and independence and a self-reliance that is characteristic of American life.

I commend the Department of Agriculture and Secretary Block for taking the initiative to organize this important conference for the sharing of research and information useful to the strengthening of the small farm in America.

You have my best wishes for a very productive and successful program.

Ronald Reagan